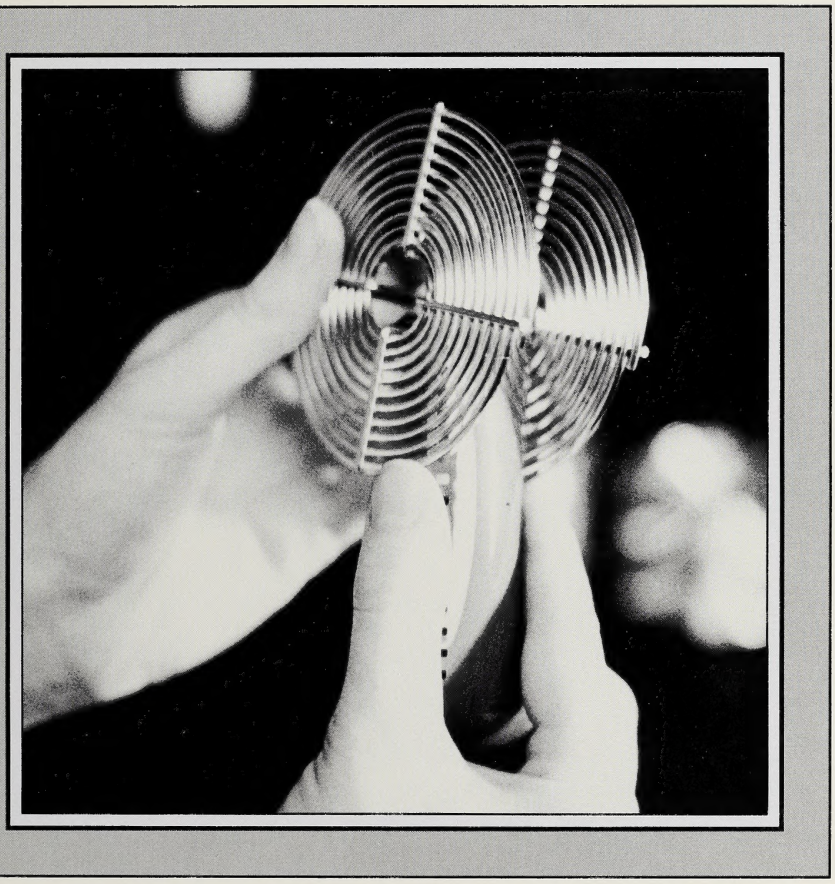
SCIENCE 24

Module 5: Exploring Metals



Distance Learning

Alberta EDUCATION

Science 24

Module 5

EXPLORING METALS

Alberta
EDUCATION

This document is intended for	
Students	✓
Teachers (Science 24)	✓
Administrators	
Parents	
General Public	
Other	

Science 24
Student Module
Module 5
Exploring Metals
Alberta Distance Learning Centre
ISBN No. 0-7741-0814-2

Welcome to Module 5!

We hope you'll enjoy your study of Exploring Metals.

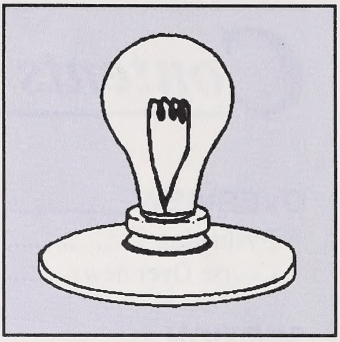
To make your learning a bit easier, a teacher will help guide you through the material.

So whenever you see this icon,

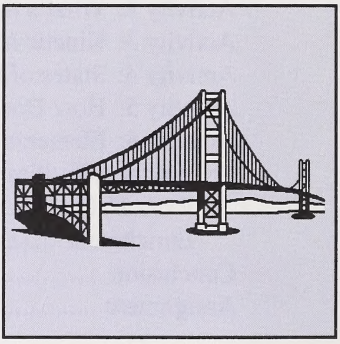
turn on your audiocassette and listen.

Contents

SECTION 3:



SECTION 4:



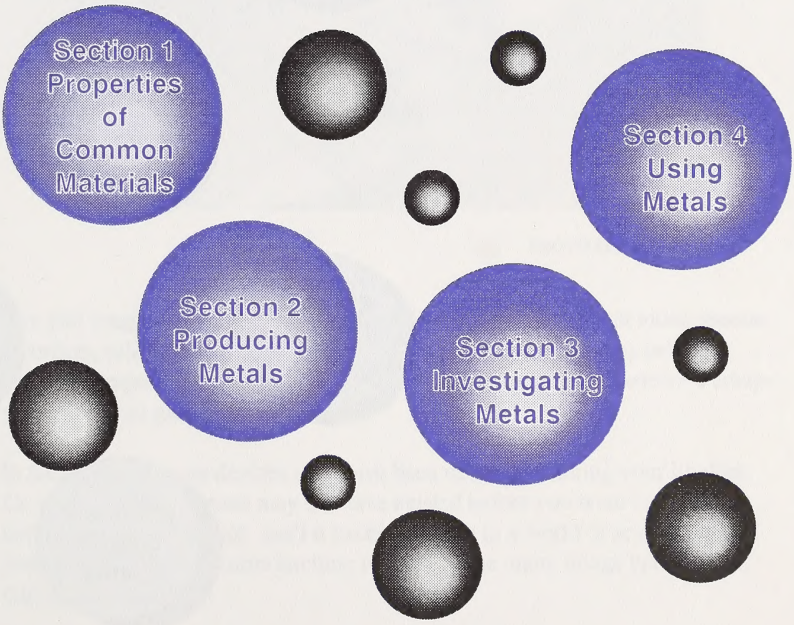
OVERVIEW

Look at everything that surrounds you right now. What do you see? Perhaps you see books, pens, glasses, furniture, and electronic equipment such as a stereo. Have you ever thought of what these items are made of?

Everything from the simplest pencil to the complex computer is made from some material. In this module you will learn to recognize that materials are substances from which objects are made. You will recognize that materials are a form of matter, and the basic structural unit is an atom. You will learn about atoms and molecules in terms of the kinetic molecular theory.

In particular you will learn about metals – one of the commonly used materials. You will come to understand how metals are extracted from ores, how metals corrode, and how corrosion can be controlled. You will investigate and evaluate properties of metals and discover how metals are used.

Module 5
Exploring Metals

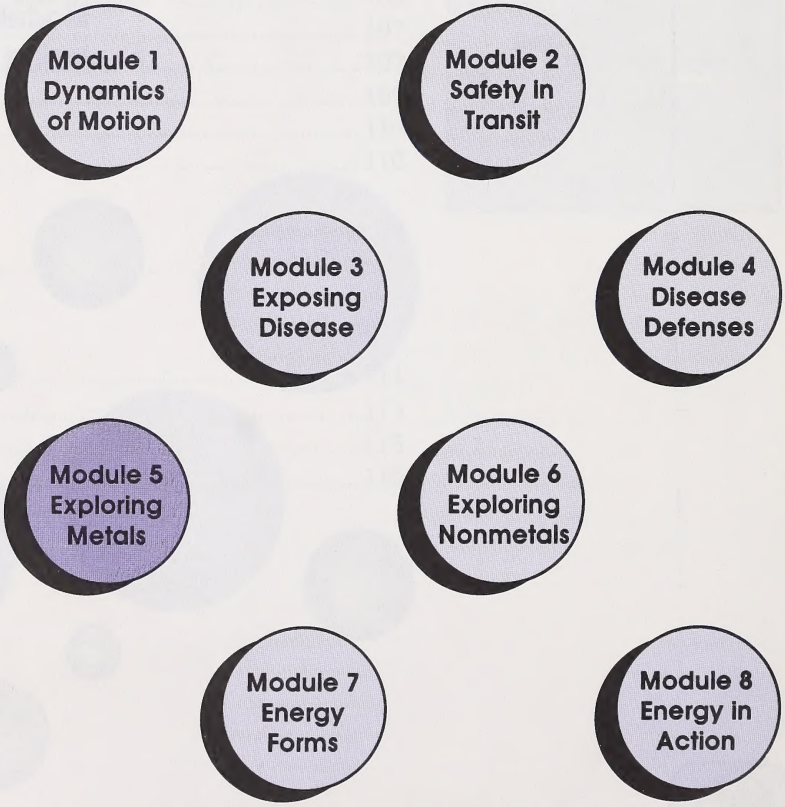


Evaluation

Your mark in this module will be determined by your work in the assignment booklet. You must complete all assignments. In this module you are expected to complete four section assignments. The mark distribution is as follows:

Section 1 Assignment	**30 marks**
Section 2 Assignment	**26 marks**
Section 3 Assignment	**20 marks**
Section 4 Assignment	**24 marks**
TOTAL	**100 marks**

Course Overview



1 Properties of Common Materials

PHOTO SEARCH LTD.

Can you imagine what your life would be like in a world without videocassette recorders, calculators, video games, compact discs, cassette tapes, cellular phones, computers, digital watches, portable radios, or ghetto blasters? Perhaps your parents or grandparents can.

In fact, some of these devices may have been developed during your lifetime. Or, some of these devices may not have existed before you were born or even before you started school. Isn't it exciting to live in a world of science and technology? It's even more exciting to think of the many things yet to come during your lifetime.

In this section you will learn about the materials that composed most of the everyday things in your life. You will then discover the building blocks of those materials – namely the atom and its various combinations.

Activity 1: What Are Materials?

Everyone uses a wide variety of products produced by **technology**.

In order for technology to provide consumer products, materials must be available so they can be converted into useful items and devices. A material is the substance from which an object can be made.

technology – applied science including all devices, products, and processes used to solve practical problems

Material Applications

1. Suggest an object or product that can be made from the following common materials.

   a. metal _____

   b. plastic _____

   c. **synthetic** fibre _____

   d. natural fibre _____

   e. fabric _____

   f. ceramic _____

   g. glass _____

   h. wood _____

   i. rubber _____

synthetic – artificially made or not found in nature

2. Which of the materials from those previous question do you think is most widely used. Why?

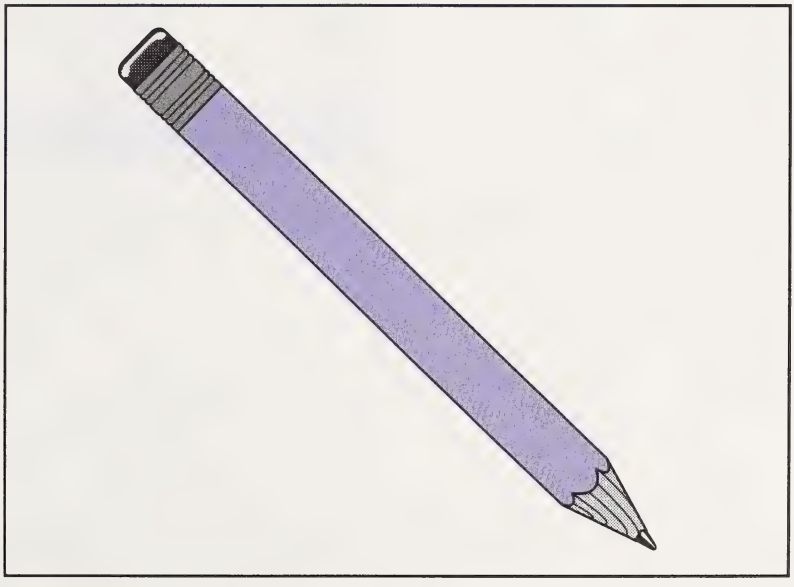
Material is made up of atoms and molecules. Products such as milk may appear to be the same throughout or made from only one kind of material. They are **homogeneous**.

homogeneous – a substance that appears to be the same throughout

If more than one kind of material is evident, that substance is said to be **heterogeneous**.

heterogeneous – a substance containing a mixture of several materials

Homogeneous and Heterogeneous Materials



In this module you will be expected to tell whether a substance is homogenous or heterogeneous by direct observation with your unaided eye. If you can see different substances within a material, you would call that material a heterogeneous mixture. For example, a pencil is a hetergeneous mixture of wood, pencil lead, paint, metal, and an eraser. The eraser is a homogenous substance because you can only see one type of material in the eraser.

Here are some examples of homogeneous materials:

- copper wire
- bowl of jelly
- can of paint
- plastic ketchup bottle
- lumber

Here are some examples of heterogeneous materials:

- jar of marmalade
- dish of stew
- jetliner
- car garage
- personal computer

3. Identify which of the following items are homogeneous materials and which are heterogeneous materials. List each item under the appropriate heading.

looney coin	credit card	milk	violin
house	newspaper	beer bottle	toilet bowl/tank
cutlery	chesterfield	electric cord	

Homogeneous Material	Heterogeneous Material
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

4. Select any **six** of the following items and identify the materials used to make them. You may want to specify the parts of the item. An example is shown.

Item	Materials
scissors	• steel • plasic • chrome
gas barbecue	
hammer	
car	
airplane	
microscope	
sneakers	

Item	Materials
personal computer	
sleeping bag	
hockey stick	
pen	
guitar	
toaster	

Check your answers by turning to the Appendix, Section 1: Activity 1.

Activity 2: What's the Matter?

PHOTO SEARCH LTD.

matter – any material that has mass and occupies space

What common materials do you recognize in this photo? Materials are commonly referred to as **matter**, and matter has its own specific properties. Anything that can be observed is matter. For example, mountains, icebergs, sugar, tidal waves, wood, iron, and tornadoes are forms of matter that have mass and occupy space.

What Is Matter?

1. Why are the three things in the previous diagram classified as matter?

Atoms

Atoms can be thought of as the building blocks of matter. It is the smallest particle of which matter is made. Similar to bricks being used to build complex buildings and other structures, atoms combine to build complex forms of matter.

Atoms are very small, so small they cannot be seen with the naked eye. Even the most powerful light microscope would not enable you to see atoms.

Modern microscopes using special techniques (like electron tunnelling) have been able to resolve a single atom. Atoms are relatively spherical as predicted by some ancient scientists.

Did You Know?

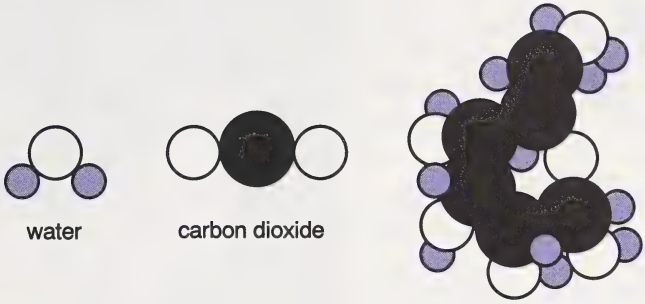
The word *atom* is derived from the Greek word *atomos* which means indivisible. The Greeks thought that the atom was the smallest particle of matter.

A common model of the atom is a sphere with different atoms being larger or smaller than others. Here are models of carbon, oxygen, and hydrogen.

hydrogen carbon oxygen

When atoms join together in chemical reactions, molecules are produced. One example is carbon and oxygen atoms combining to form carbon dioxide.

The following diagrams illustrate models of some common molecules.



2. If molecules were broken apart, what would the result be?

_____

_____

3. How many different kinds of atoms are found in the sugar (glucose) molecule?

_____

_____

4. What is the total number of atoms in the sugar (glucose) molecule?

_____

_____

Check your answers by turning to the Appendix, Section 1: Activity 2.

Activity 3: Kinetic Molecular Theory

PHOTO SEARCH LTD.

How does the water is an ice cube tray turn into solid ice cubes? How does an ice cube in your hand melt into cold water? How does water in a kettle turn into steam?

There are some simple answers to these questions. Water turns to ice when it becomes cold enough to freeze. Ice melts into water when it becomes warm. Water becomes steam and evaporates when it becomes hot enough. However, observant people noticed that water evaporates even when it is not boiling. Even ice can turn to water vapour at below-freezing temperatures. A simple answer no longer explains these questions. Scientists have had to look for better answers to these questions. The combined answer is the kinetic molecular theory.

kinetic energy – energy due to motion

Anything that moves is said to possess **kinetic energy**. Scientists believe that atoms and molecules are constantly in motion. This is difficult to understand, because there are so many things that don't seem to move but are actually in motion. How can the atoms that make up this paper be moving? If those atoms were moving, wouldn't the page be actually moving?

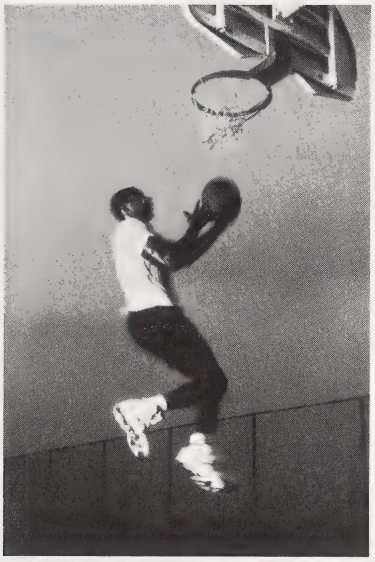
analogy – a simpler, more visual situation, used to explain a more difficult or abstract idea

To give you a better understanding of the idea that atoms and molecules are constantly in motion, you will use an **analogy**. Imagine yourself in a group situation such as in a quiet class, on a basketball team, or at a dance. You are going to be playing the part of atoms and molecules in the following analogies.

Imagine yourself in a quiet class where everyone is sitting in their own desk reading this page. Is anyone moving? No, everyone is sitting at their own desk. If you look more closely, you will realize that there is motion in the room. Your eyes are moving, you are breathing, and your hands and feet are moving. You will notice that everyone else is moving as well. The class is much like the molecules in this page. The molecules in this page are fixed into place the same way the students in the classroom are fixed into their desks. All the molecules of this page are moving within their fixed place.

Despite all of the motion, the molecules in the page keep the shape of the page, just like the students in their desks keep the shape of a class of students.

Now imagine yourself at a dance. You go by yourself, find a partner, and begin to dance a slow dance. You and your dance partner are analogous to a molecule (made of two atoms) moving about in a liquid state. The dancers move about the dance floor, sliding past one another, sometimes colliding with one another, but always moving around the whole dance floor. This is analogous to how molecules in a liquid behave. They move past and collide into other molecules while still keeping the shape of the container.



NASA

Now imagine yourself to be part of a basketball team. You move quickly and sometimes violently collide into other players. Sometimes you jump high in the air and slamdunk the ball. This is analogous to molecules of a gas. The molecules move quickly, violently bump into each other, and occupy the entire volume of the container.

1. Match the following ideas of the kinetic molecular theory with the corresponding human activity.

_____	a. Molecules are constantly in motion.	A. Dancers on a dance floor move about all over the dance floor.
_____	b. Molecules in a solid move within a fixed position.	B. Dancers on a dance floor move past one another.
_____	c. Molecules in a liquid slide past one another.	C. Dancers dance faster when the tempo of the music increases.
_____	d. Molecules in a gas state move faster and farther than molecules in a liquid or solid state.	D. People are constantly moving twenty-four hours a day.
_____	e. Molecules in a liquid move randomly.	E. The motion of players in a basketball game is much faster than the motion of dancers or students in a classroom.
_____	f. Molecules move faster when the substance is heated.	F. A classroom of students quietly reading at their desks is in constant motion.

When the music stops in the dance hall, the dancers stop dancing and may even sit down.

2. If the dancers are analogous to the molecules of a liquid, to what is the music analogous?

_____

_____

Check your answers by turning to the Appendix, Section 1: Activity 3.

Activity 4: States of Matter

Matter exists in three common states: solid, liquid, and gas. While analogies are often useful, **models** are sometimes a better way to illustrate ideas.

Investigation: Models of Matter

model – a three-dimensional representation of something

In this investigation you will use miniature marshmallows to model the states of matter.

Materials You Need

- bag of miniature marshmallows (multi-coloured ones work best)
- 1 L clean jar

Steps to Follow

STEP A	OBSERVATION
Fill your jar with marshmallows. Get as many as you can into the jar; then put on the lid. Turn the jar upside down and shake it.	1. Did you see the marshmallows moving around in the jar? _____ 2. The marshmallows are models of the atom. What is the state of matter that is being modelled in this step? Explain. _____ _____ _____ _____

STEP B

Take about half of the marshmallows out of the jar. Replace the lid on the jar, and slowly shake the jar from side to side. Turn the jar upside down.

OBSERVATION

3. Did you see the marshmallows moving around in the jar?

_____

4. What is the state of matter that is being modelled in this step? Explain.

_____

_____

_____

_____

STEP C

Take half of the remaining marshmallows out of the jar. You should now have one-quarter of the jar filled with marshmallows. Replace the lid and shake the jar vigorously. Watch the contents of the jar carefully.

OBSERVATION

5. Did you see the marshmallows moving around in the jar?

_____

6. What state of matter is being modelled in this step? Explain.

_____

_____

_____

Conclusions

7. Models often fail to completely describe something. What was the most serious flaw in the marshmallow model of a liquid?

_____

_____

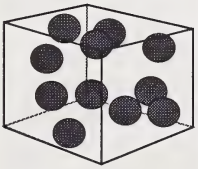
8. Why would multi-coloured marshmallows work better than plain, white marshmallows?

_____

_____

Check your answers by turning to the Appendix, Section 1: Activity 4.

The properties for each state of matter can be explained by using molecular models similar to those constructed.

State	Model	Property
solid		• It has definite shape and volume. • Molecules are neatly arranged with little space between them. • Molecules can only vibrate.
liquid		• It has definite volume but assumes the shape of the container. • Molecules are close together with some space between them. • Molecules vibrate faster than in solids and have freedom of motion.
gas		• There is a lack of definite shape and volume. • There are very large spaces between molecules. • Molecules vibrate faster than in liquids and solids and they also migrate. • Molecules move freely in all directions.

9. Under each heading (Solids, Liquids, and Gases), list five common household items.

Solids	Liquids	Gases
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Check your answers by turning to the Appendix, Section 1: Activity 4.

Activity 5: How Does Matter Change?

Did you ever go ice fishing or water skiing on the same body of water? Only one of these activities can be done at a time depending on the phase of the surface of the water.

When matter is heated or cooled it can be changed from one phase to another. The phase changes have special scientific names. (The common names appear in brackets.)

Changes Requiring Heat	Name
solid to liquid	fusion (melting)
liquid to gas	evaporation (boiling)
solid to gas	sublimation
Changes Requiring Cooling	**Name**
liquid to solid	solidification (freezing)
gas to liquid	liquification (condensation)
gas to solid	sublimation

1. Using the scientific names, identify the phase changes involved in the following observations.

   a. Dry ice is made from carbon dioxide gas. _____

   b. Surfaces of lakes freeze during winter. _____

   c. Mothballs produce an odour and get smaller with time. _____

   d. Wet clothes become dry on a clothes line. _____

   e. Eye glasses fog up in winter when a person enters a warm room from outdoors. _____

   f. Icebergs get smaller as they enter warmer waters. _____

   g. You can see your breath when the temperature is 2°C. _____

   h. Streets become dry after a rain. _____

   i. Metal is cut with a torch. _____

Check your answers by turning to the Appendix, Section 1: Activity 5.

Physical and Chemical Changes

physical change – any change in which the form of matter is different from the original without forming a new substance

chemical change – any change where a new substance is formed

When matter changes its state but the substance itself remains the same, the change is a **physical** one. For example, when water solidifies into ice or evaporates into water vapour, only the form of matter has been changed. Ice, water, and water vapour are only different forms of the same substance.

When a new substance is formed from the original, the change is a **chemical** one. When charcoal burns to produce heat, gases, and ash, new substances that are different from the original have been formed.

2. For each of the following changes, decide whether the change is chemical or physical, and state the reason why.

   a. Gasoline explodes in the cylinder of a car.

   _____

   _____

b. Gravel can be crushed into smaller pieces.

_____

_____

c. Milk turns sour.

_____

_____

d. Bananas rot.

_____

_____

e. Lumber is made from trees.

_____

_____

f. Sheets of aluminum are pressed into cans.

_____

_____

g. Silverware tarnishes.

_____

_____

h. Nails are made from iron.

_____

_____

Check your answers by turning to the Appendix, Section 1: Activity 5.

Activity 6: Elements and the Periodic Table

What are you made of? Have you ever had to supplement your body with something it is lacking? Have you ever taken mineral supplements? Why does your body need minerals?

Your body is composed of a large number of compounds. The foods you eat contain the minerals needed for body growth and maintenance. If you don't get enough of the proper minerals from the food you consume, your doctor may recommend mineral supplements. Some of these minerals are iron, calcium, phosphorus, sulphur, iodine, as well as many others. What are minerals? Minerals are also known as **elements.**

element – a substance containing only one kind of atom

Each element has its own physical and chemical properties. For example, carbon is a black solid which burns in oxygen, while nitrogen is a colourless gas which is relatively unreactive.

periodic table – an arrangement of elements in order of atomic number and properties

Certain elements have similar chemical and physical properties. These elements are grouped into columns in the **periodic table.** For example, the noble gases in group 18 are all unreactive gases at room temperature.

Every element has been given a name, a symbol, and a number. These names, symbols, and numbers are recognized world-wide. Atoms of the elements cannot be broken down into simpler parts by ordinary reactions.

1. Use the periodic table to complete the following table.

Atomic Number	Symbol	Name
1		
	Li	
		carbon
12		
	P	
		chlorine
20		
	Fe	

Atomic Number	Symbol	Name
		germanium
	Ag	
74		
		mercury

2. If *element* is another word for mineral, why is it used to describe the substances in the periodic table?

3. How many elements have been discovered so far?

Check your answers by turning to the Appendix, Section 1: Activity 6.

Did You Know?

The body of a 75 kg person contains enough phosphorus to make about 1000 matches, enough carbon to make about 14 kg of charcoal briquettes, and 34 125 L of oxygen, which is enough oxygen to fill a large bedroom.

The periodic table is divided into two sections – metals and nonmetals. Look at your periodic table. Starting to the left of element five, boron, go down from left to right. You will notice a dark line that looks like a staircase. All elements to the left of this staircase have properties of metals. All elements to the right of this staircase have properties of nonmetals. Elements close to the staircase sometimes have both metal and nonmetal properties.

4. Use your periodic table to classify the following elements as metals or nonmetals.

Symbol/Name	Metal/Nonmetal
iridium	
Te	
vanadium	
Cr	
Au	
argon	
selenium	
F	
barium	
Br	

Check your answers by turning to the Appendix, Section 1: Activity 6.

Did You Know?

Of the 107 known elements, only 92 occur in nature. That means there are 15 elements created synthetically. Where are these synthetic elements made? They are made in nuclear reactors or in particle accelerators. Often these synthetic elements are very radioactive and will last for only short periods of time before they decay into more stable elements.

Compounds

Do you watch TV quiz shows? Would you like to be a contestant and win some of those fabulous prizes? How many questions could you answer? Suppose you were asked for the formula for water. What would your answer be?

Water is an example of a compound composed of two elements. When the elements hydrogen and oxygen unite, water is formed. The elements can no longer be identified by their original chemical or physical properties. You can't see the hydrogen or the oxygen in water.

Similarly, sodium metal and chlorine gas combine chemically to produce table salt. Such properties as colour, taste, odour, and solubility of the compound are now distinctly different from the properties of the elements producing the compound. Can you see the chlorine in table salt?

5. State which of the following substances are elements and which are compounds. Compounds cannot be found on the periodic table.

carbon dioxide	baking soda	iron	mercury
alcohol	propane	table sugar	silver
calcium	carbon	zinc	vinegar

Element	Compound

Check your answers by turning to the Appendix, Section 1: Activity 6.

Compounds are made of molecules. The chemical formula of a compound indicates which atoms are present in the molecule. For example, the formula for water is H_2O. The water molecule contains two atoms of hydrogen and one atom of oxygen.

Some other formulas for common compounds are shown in the following chart.

Substance	Formula	Atoms Present
sugar	$C_6H_{12}O_6$	6 carbon 12 hydrogen 6 oxygen
table salt	NaCl	1 sodium 1 chlorine
natural gas	CH_4	1 carbon 4 hydrogen
ammonia	NH_3	1 nitrogen 3 hydrogen
rust	$Fe_2O_3 \cdot 3H_2O$	2 iron 6 oxygen 6 hydrogen
propane	C_3H_8	3 carbon 8 hydrogen

Mixtures

How can you tell the difference between elements, compounds, and mixtures? Here are some guidelines to follow when classifying matter into these categories.

- An element is found in the periodic table of elements. If you cannot find the substance in the periodic table, it is not an element.
- A compound is made of two or more substances blended together but not chemically combined. Parts can be separated from the mixture.
- A compound is made of two or more elements chemically combined. The chemical formula or the chemical name of a substance will identify the substance as a compound.

There is an infinite range of mixtures. Imagine a mixture of flour and sugar. You could have a small amount of flour mixed with a large amount of sugar, a large amount of flour mixed with a small amount of sugar, or you could have any other possible combination. All of these combinations are mixtures.

There are mixtures which contain elements, and there are compounds where the elements are very hard to separate. Some parts of mixtures may even chemically combine to form new products. As long as there are parts which have not chemically combined, it is a mixture. An example of this kind of mixture is concrete. A mixture of sand, cement, and water is left to harden. The cement and water chemically react, but the resulting concrete is still a mixture because the sand and cement-water compound is not chemically combined.

There are mixtures which have different physical and chemical properties than the original compounds have. An example is the ethyleneglycol-water mixture, commonly known as antifreeze. The mixture has a boiling point and a freezing point that are different from each of the two substances from which it was made. The mixture also has different chemical properties than either water or ethyleneglycol.

6. State which of the following substances are mixtures and which are not mixtures.

- soil
- sugar
- air
- crude oil
- distilled water
- sea water
- zinc
- milk

Mixtures	Not Mixtures

7. What are some of the main ingredients or components of the following mixtures?

   a. soft drinks

   _____

   _____

   b. air

   _____

   _____

   c. paint

   _____

   _____

   d. pavement

   _____

   _____

   e. 10 karate gold ring

   _____

   _____

Check your answers by turning to the Appendix, Section 1: Activity 6.

Follow-up Activities

If you had difficulty understanding the concepts in the activities of this section, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

To help you to master the concept of materials, composition, changes of matter, and the kinetic molecular theory, read the following information thoroughly.

- All things are made from materials. Common materials from which things are made include metals, plastics, fabrics, ceramics, glass, and wood.
- Matter is anything which occupies space, has mass, and exists as a solid, liquid, or gas.
- Matter is made up of atoms and molecules. Scientists believe that these particles are in motion.
- The kinetic molecular theory states that the molecules which make up matter are always in motion. The higher the temperature, the faster the molecules move.
- Solid matter has a definite shape and volume. Its molecules can only vibrate in place.
- Liquid matter has a definite volume. A liquid takes the shape of its container. Its molecules are close together but not as neatly arranged as in a solid. They have some freedom of movement compared to a solid.
- Gaseous matter does not have a definite shape or volume. The space between molecules is very large, which allows the molecules to move freely in any direction.
- When matter is heated or cooled, it can change its state. Since a new substance is not formed and the same matter still exists, the change is a physical one.
- A chemical change occurs when matter changes to produce an entirely different or new form of matter.
- Most elements are made up of atoms. They are a form of matter which contains only one kind of atom. Some elements such as hydrogen and oxygen are made of molecules but still have only one kind of atom.

- There are 107 known elements which are listed and organized on a periodic table.
- Compounds are composed of two or more chemically combined elements. Therefore, a molecule of a compound contains two or more different atoms which are chemically bound together.
- Mixtures are formed when different substances are mixed together. The substances do not unite chemically and can be separated by ordinary means.

1. Identify some common materials used to make the following products.

   a. cassette tape _____

   b. mirror _____

   c. ski suit _____

   d. chess pieces _____

   e. pots and pans _____

   f. flower pot _____

   g. kitchen stove _____

   h. cardboard box _____

   i. ketchup bottle _____

2. Why is a cloud considered to be matter?

   _____

   _____

   _____

   _____

3. Place a T in front of the statements that are true and an F for those that are false. Correct any false statements.

_____ a. Nylon is a material; therefore, it is a form of matter.

_____

_____ b. Air is matter; therefore, it has mass and occupies space.

_____

_____ c. A molecule is the smallest particle of an element.

_____

_____ d. The kinetic molecular theory states that when water freezes, molecular motion ceases.

_____

_____ e. The kinetic molecular theory explains why a gas does not have a definite shape.

_____

_____ f. According to the kinetic molecular theory, gases have the least amount of space between their molecules.

_____

_____ g. When you barbecue hamburgers, a chemical change occurs.

_____

_____ h. A molecular formula only indicates the type of atoms present in the molecule.

_____

_____ i. Antimony is an example of an element.

_____

_____ j. Carbon dioxide is an example of a compound.

_____

_____ k. Air, which is a gas, can be changed into a liquid.

_____

4. Fill in the blanks.

   a. Sulphur is an element; therefore, it contains only _____ _____ of atom.

   b. The formula for baking soda is $NaHCO_3$. The elements that baking soda is made from are _____, _____, _____, and _____.

   c. The space between molecules in gases is _____.

   d. The state of matter that has a definite volume is a _____ or _____.

5. Read each question and decide which of the choices best completes the statement.

   _____ a. Aluminum is considered to be an element because

   A. it is widely used
   B. its atoms can only vibrate
   C. it only contains identical atoms
   D. it occupies space and has mass

   _____ b. Concrete is made from water, cement, sand, and gravel. It is an example of

   A. a mixture
   B. an element
   C. a compound
   D. a molecule

Check your answers by turning to the Appendix, Section 1: Extra Help.

Enrichment

1. Some of the essential elements needed by your body are listed. Use any outside reference source, such as a biology textbook or encyclopedia, to find the specific use for any **ten** of the following elements that your body needs.

   a. potassium _____

   _____

   b. magnesium _____

   _____

   c. sodium _____

   _____

   d. calcium _____

   _____

   e. chlorine _____

   _____

   f. phosphorus _____

   _____

   g. copper _____

   _____

   h. cobalt _____

   _____

   i. zinc _____

   _____

   j. iodine _____

   _____

k. fluorine _____

_____

l. iron _____

_____

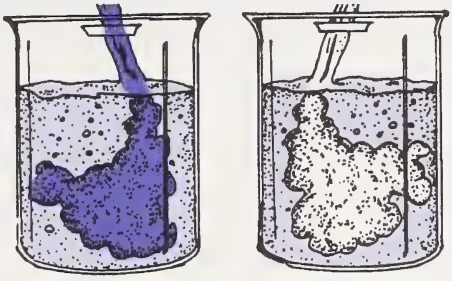
m. sulphur _____

_____

Investigation: Brownian Motion

In this investigation Brownian motion, or the spreading of particles throughout a solution, will be observed. This spreading is called **diffusion** and was first observed by a Scottish botanist, Robert Brown.

This investigation involves motion and collision of water and food colouring molecules in a solution. As water molecules collide with food colouring molecules, it causes them to spread throughout the solution. The number of collisions is affected by temperature and concentration. Concentration refers to the amount of food colouring per volume of water. Concentration increases as more food colouring is added to the water.



Materials You Need

- red or blue food colouring
- two clear, glass containers, or two clear plastic cups
- cold and hot water

Steps to Follow

STEP A

Fill one beaker full of cold water and another with hot water. Add a drop of food colouring to each container.

STEP B

Observe how the colour spreads throughout the water in both containers for about five minutes.

STEP C

Fill two beakers or glasses with water of the same temperature. Add one drop of food colouring to one container and five drops to the other container.

STEP D

For about five minutes, observe how the colouring spreads throughout the water in both containers.

Observations

2. In which container does the food colouring spread more quickly?

_____

Conclusions

3. What causes the food colouring to diffuse in water in Step A?

_____

_____

4. From your observation of Step A, what conclusion can be made about the effect of temperature on the diffusion of food colouring in the water?

_____

_____

5. What conclusion can be made about the effect of concentration on the diffusion of the colouring in water in Step B?

_____

_____

6. Why does Brownian movement of particles occur in gases such as air and in liquids such as water?

_____

_____

_____

_____

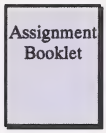
Check your answers by turning to the Appendix, Section 1: Enrichment.

Conclusion

Technology uses a wide variety of materials to make items consumers enjoy. The composition and properties of materials that make them useful to their applications should be appreciated by everyone.

Common materials are turned into components of living things by living organisms. Common materials are turned into useful products by technology. Elements combine to form compounds. Your world is composed of elements and compounds. Elements are classified as metals and nonmetals.

Knowledge of the composition and properties of matter enables people to make good use of the compounds in the world.

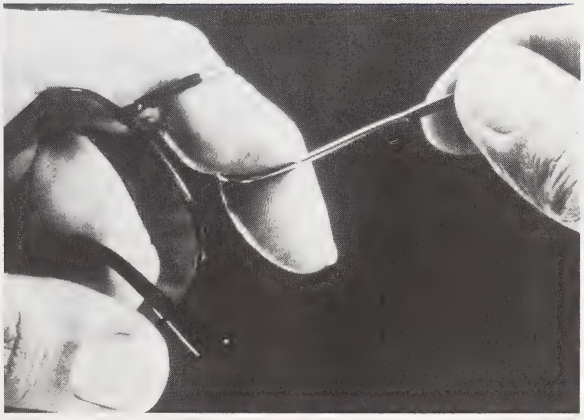


ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 1.

2 Producing Metals

ALBERTA PUBLIC AFFAIRS BUREAU



NASA

If your metal eyeglass frames were bent out of shape and needed to be replaced, could you simply go to the minerals and rocks that contain the metal your glasses are made from and get new metal? The answer would be no. However, metals are extracted from the minerals in which they are found, and these metals are then developed into products for everyday use.

You will study metals by learning about the development of metallurgy. You will learn how metals are extracted from minerals. You will recognize metals, nonmentals, and alloys. You also will learn about corrosion – how it forms and how it is prevented.

Activity 1: What Is Metallurgy?

Have you ever seen a meteor shower? Meteorites often contain amounts of iron, nickel, and other metals. Did prehistoric people wonder what meteorites were made of? The rocks that fell from the sky seemed to be different from ordinary rocks. Even if people thought there might be some useful substance in the meteorites, they had no way of getting it out.

How Are Metals Produced?

Probably one of the first metals to be used by humans was gold. Gold can be found in its pure state and in large nuggets. Rivers concentrate the gold because the gold is more dense than ordinary rock. Gold is very soft and easily could be hammered into jewellery and ornaments. It is too soft to make useful tools.

Today most of the gold must be extracted from the earth using expensive mining technology and chemical separation and purification techniques. Unfortunately most of the gold in rivers and riverbeds has already been found and removed. You can still find small quantities of gold using timeless methods such as gold panning.

Did You Know?

The amount of gold produced in the world since time began would cover a football field from ground level to slightly above your knees. Gold is continually recycled and most of the gold found is still in use today. If you have any gold object, it is possible that the same gold was at one time part of an ancient object such as Cleopatra's jewellery.

1. Why is gold found in its pure form while most other metals are found combined with other elements?

Copper was discovered by prehistoric people because it could often be found in its purest form. People learned that a copper blade was superior to one made of stone because it could more easily be pounded into a sharper edge and resharpened when needed. Copper was sometimes used in jewellery, as well as in tools.

Tin was another metal discovered in prehistoric times. It probably was easily accessible because of its low melting point (232°C). Unfortunately, tin is a soft metal and not very useful for making tools.

Alloys

alloy – a mixture of two or more metals

Bronze Age – the period between 4000 BC and 3000 BC during which bronze was used to make weapons and tools

metallurgy – the science of extracting metals from ore and changing them into useful products

smelting – the process of extracting metal from its compound by heating it

Whether by accident or through careful planning, copper and tin were melted together. The result of this mixture was an **alloy**. This alloy was called bronze, and it had new and interesting qualities. Bronze is harder and stronger than either copper or tin. Sharp, long-lasting tools were made from bronze. It was such a useful alloy that an age of human history was given its name, the **Bronze Age**. This time period was between 4000 BC and 3000 BC. It was probably during this period that **metallurgy** was begun.

Copper was obtained in large quantities by **smelting** the mineral azurite in special fires fueled with charcoal. Large quantities of tin were also obtained from tin ores by smelting.

The smelting processes used to produce copper and tin were refined until someone produced iron, probably by accident. Iron was harder than bronze. Iron ores must have been more plentiful, and iron was deemed to be a superior metal. The Iron Age came after the Bronze Age, and some consider the Iron Age to still be in effect.

The process of smelting iron from iron ore using charcoal produces another alloy. Iron and carbon produce an alloy called steel. The qualities of steel vary greatly as the amount of carbon varies. Cast iron, construction steel, nails, chisels, car parts, and several other products used in your life are steel products. Most of these steels vary in the amount of carbon contained in the alloys from almost zero up to 4.5%. Modern steels are made using an incredible variety of metals and even some nonmetals as important ingredients of the alloys. Modern stainless steels resist corrosion and yet easily form into any shape.

2. Who were the first metallurgists?

_____

_____

3. Why was bronze preferred to copper?

_____

_____

4. The carbon from charcoal used in smelting copper would contaminate the metal. Why doesn't carbon contaminate iron in the same way?

_____

_____

_____

Modern Metals

Many metals are produced today by complex chemical and physical processes which were not possible even a few hundred years ago. Electricity often plays a major role in the production of metals because it can be used to purify the metal and to separate the metal from the ore. Aluminum is one of the most common metals which requires a vast amount of electrical power in its production. In fact, aluminum is never found in its pure state in nature and it cannot be separated from its ore, bauxite, by smelting. Aluminum is refined in British Columbia and in Quebec. Some other modern metals are chromium, cobalt, vanadium, and tungsten. These metals have specialized uses because of their unique properties.

Metals have the following common physical properties:

- shiny or lustrous
- good conductor of heat and electricity
- ductile (capable of being drawn into wire)
- malleable (can be hammered into thin sheets)
- high melting points (for most metals)

Some of the metals are very useful in their pure state, but most metals are mixed to produce alloys with very specific properties. Here is a list of some common alloys detailing their composition, properties, and uses.

Alloy	Composition	Properties	Uses
stainless steel	Fe, C, Cr, Ni	• resists corrosion • shiny	surgical instruments, kitchen ware
chromium steel	Fe, C, Cr, Ni	• resists corrosion • hard, strong	ball bearings

Alloy	Composition	Properties	Uses
vanadium steel	Fe, C, V	• very strong	tools, auto parts
German silver	Cu, Ni, Zn	• resists corrosion • shiny	imitation silver
babbit	Sn, Sb, Cu	• low friction	bearings
brass	Cu, Zn	• resists corrosion	plumbing fixtures, keys, bed frames
cast iron	Fe, C	• very hard • can be cast	old engine blocks, some frying pans
solder	Sn, Pb	• low melting point	joining metal
amalgam	Ag, Cu, Sn, Zn, dissolved in Hg	• hardens quickly and permanently	tooth fillings
sterling silver	Ag, Cu	• resists corrosion • shiny	silverware, jewellery

Of all the metals, iron is one of the most inexpensive, easiest to produce, and easiest to form metals. Unfortunately, it reacts very quickly when exposed to water and air. The product, rust, is useless. In order to make products using iron as the base and still have the corrosion resistance of more noble metals, a process known as plating is used. The iron or steel is covered with a thin layer of zinc, tin, chromium, or another metal to produce a relatively inexpensive, but functional, product. Some examples are tin cans, galvanized steel, and chrome-plated items such as scissors, plumbing fixtures, and auto parts.

5. Most of the modern metals were discovered in the last two or three hundred years. Why were all these metals so difficult to discover?

_____

_____

_____

_____

6. Canada produces a large amount of aluminum each year, yet Canada has to import all of the bauxite used. Why do they have an aluminum plant in British Columbia?

_____

_____

_____

7. Predict whether alloys or plated steel would be used in each of the following applications.

   a. eavestrough: _____

   b. car bumper: _____

   c. screwdriver: _____

   d. wrench: _____

   e. eating utensils: _____

   f. frying pans: _____

   g. plumbing pipes: _____

   h. knives: _____

8. Using the periodic table in the appendix, record the melting point for the following metals.

   a. iron _____

   b. copper _____

c. lead _____

d. antimony _____

e. tin _____

f. silver _____

g. mercury _____

h. gallium _____

Check your answers by turning to the Appendix, Section 2: Activity 1.

Activity 2: What Is Corrosion?

Are you familiar with the expression "… ashes to ashes, dust to dust"?

In a sense corrosion represents the attempt of metals to return to their original compound state. When metals corrode, they lose their metallic properties. Pure copper is bright and shiny like a new penny. When copper corrodes, it turns a dark, dull brown and may even take on a greenish colour which is similar to the ore from which it is obtained.

Did You Know?

It is estimated that 20% of the iron and steel that is produced annually is used to replace that lost to corrosion.

Oxides

Metals rarely exist in their pure state. Oxygen is a very common nonmetal found in the atmosphere, and it will combine with most pure metals to produce a metal oxide. The metal oxide does not have any of the characteristics of the metal. A strong iron support in a car frame can **oxidize** into a weak, flaky oxide which breaks and no longer supports the car. The common name for iron oxide is rust.

oxidize – react with oxygen

There are some interesting uses of metal oxides. Milk of magnesia is an antacid which people drink to help an upset stomach. Milk of magnesia contains the active ingredient magnesium oxide (MgO). Aluminum quickly oxidizes into aluminum oxide when exposed to the oxygen in air. Aluminum oxide is a very stable compound, and it prevents further oxidation of the aluminum metal. Zinc has similar characteristics. When an iron or steel object is plated with zinc, the zinc coating protects the iron in two ways. Firstly, the zinc will oxidize before the iron. Secondly, the surface of the zinc quickly oxidizes and forms a protective coating of zinc oxide. This prevents the zinc metal from further oxidizing.

Did You Know?

Metals that are easiest to obtain from their ores oxidize the slowest.
Metals that are hardest to obtain from their ores oxidize the fastest.

1. Why do you think an iron nail rusts so quickly compared to an aluminum nail?

_____

_____

_____

2. Why is a metal garbage can galvanized?

_____

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 2.

Investigation: Rusting of Iron

In this investigation you are going to find out what factors influence the rusting of iron. When iron is exposed to certain conditions, rusting is a common result of chemical changes.

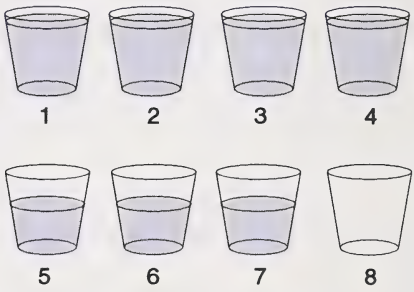
Materials You Need

- 8 10-cm lengths of iron wire or common uncoated nails
- 8 test tubes, glass containers, or clear plastic cups
- 1 10-cm length of copper wire
- steel wool
- transparent tape
- 5 mL table salt
- 3 mL copper (II) sulphate, $CuSO_4$, or copper (II) carbonate, $CuCO_3$
- 10 mL hydrochloric acid

Steps to Follow

STEP A

Label the eight containers from 1 to 8. Fill containers 1 to 4 with water. Fill containers 5, 6, and 7 half-full with water. Leave container 8 empty.



STEP B

Add 5 mL (one teaspoon) of table salt to container 5. Add 3 mL of $CuSO_4$ or $CuCO_3$ to container 6. Add 10 mL of hydrochloric acid to container 7.

Caution: Hydrochloric acid is corrosive. Wear eye goggles and handle the acid carefully. If you get any acid in your eyes or on any part of your body rinse thoroughly with water. Call a physician.

STEP C

Clean all of the uncoated nails, or iron wires, with steel wool, and place one in each of containers 4, 5, 6, 7, and 8.

5 6 7

STEP D

Bend another nail two or three times, and place it into container 1.

1

STEP E

Wrap another nail with transparent tape, and place it into container 2.

2

STEP F

Wrap the copper wire around another nail in a spiral (similar to tape around a hockey stick), and place it into container 3.

3

Leave the nails in the containers over a two-day period of time.

Observations

3. Complete and record your observations in the following chart.

Corrosion of Iron			
Container Number	**Content Descriptions**	**Day 1 Observations**	**Day 2 Observations**
1			
2			
3			
4			
5			
6			
7			
8			

4. Which container is the control?

_____

5. In which container did the iron rust the most?

_____

6. In which container did the iron rust the least?

_____

Conclusion

7. What generalization or conclusion can be made about the rusting of iron?

_____

_____

_____

_____

8. Something occurred in containers 6 and 7 that was different from the rusting process in containers 1 through 4. Can you explain what happened that was different?

_____

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 2.

Preventing Corrosion

Rusting iron is only one form of corrosion. If you leave the iron in the acid solution for a longer period of time, you can easily see pits in the smooth surface. You might see the iron becoming flaky. If left long enough, the iron might rust severely. The iron in the copper (II) sulphate solution experienced a very different type of corrosion. The reddish substance on the nail was not rust, it was copper. Atoms of iron were removed and replaced by copper, which would reduce the strength of the iron.

Have you ever seen a very rusty vehicle? The fenders seem to be falling off, and there are holes right through the car's body parts. All kinds of corrosion have ruined the car. Chemical corrosion from acids in the air to salt on the road have corroded the metal. How can the car's iron parts be protected from corrosion?

The most obvious line of defence is paint. Paint keeps water and corrosive chemicals from attaching to the thin iron or steel body. Parts which are much thicker, such as beams or motor casing, do not require paint because they will not corrode in the lifetime of the car. Look carefully at a car with small rust spots on the body. The paint was chipped or flawed in those places, therefore allowing water and chemicals to corrode the steel underneath. By painting the car, the steel underneath is protected.

Corrosion also occurs another way in vehicles. There are two sides to the metal of a car door and fender. If water and corrosive chemicals can get to the metal from the inside, the car can rust from the inside out. Rust-proofing after the car is completely manufactured is often done as soon as the car is purchased. Special chemicals are sprayed onto all of the inside and underneath body parts. Car manufacturers are using galvanized steel, aluminum, and plastic for body parts to reduce the corrosion of vehicles. Keeping the vehicle clean and dry, as well as fixing any paint chips and repairing rusted spots, will reduce corrosion.

9. Suggest how the paint coat on a car can be broken.

_____

_____

10. Suggest four car parts where chrome-plating is used.

_____

_____

_____

_____

11. Why do automakers chrome-plate these kinds of parts?

_____

_____

_____

12. Why do automakers use galvanized steel to make most body parts?

_____

Did You Know?

It takes four years to paint the Golden Gate Bridge from one end to the other; then the process is started all over again.

13. Why is corrosion of an unpainted steel bridge dangerous?

_____

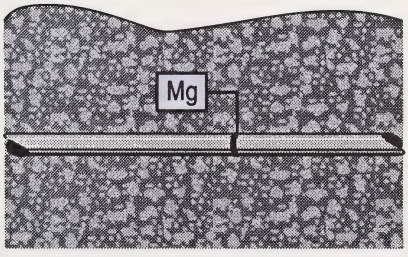
_____

Painting, chrome-plating, and galvanizing are not the only means of preventing the corrosion of iron steel.

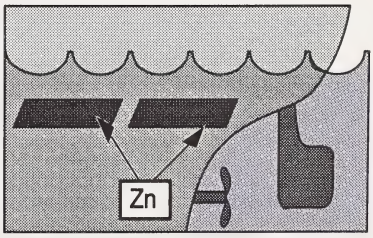
Have you ever eaten food which was stored in a tin can? A tin can is really a steel can with a thin layer of tin plated onto it. The tin coating is corrosion resistant.

Cathodic protection using a sacrificial anode is another way of producing the corrosion of iron on ships, pipelines, and storage tanks. A metal which corrodes faster than iron is attached to the iron needing protection. Zinc and magnesium are two common metals used in this method. The explanation as to how it works is quite complicated but can be reduced to this simple idea. When a metal corrodes it loses electrons. If you have two metals connected together, the metal which corrodes easiest will lose its electrons first. This prevents the metal that corrodes less from losing its electrons. In a steel ship the steel will not corrode until all of the magnesium or zinc metal attached to it corrodes away completely. Whenever this sacrificial anode method is used it is very important to replace the sacrificial metal before it is all used up. If the owners of a ship forget to replace the sacrificial anode, the hull of the ship will quickly rust away.

Sacrificial Anode



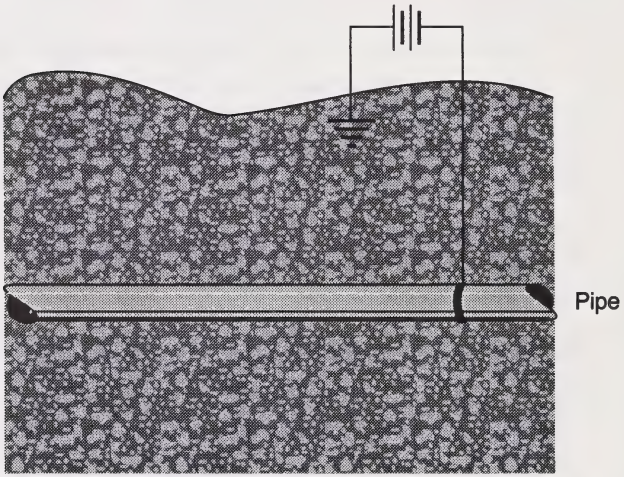
Underground pipe



Ship

Impressed voltage cathodic protection is another modern way of protecting iron and steel pipelines and storage tanks. A battery is connected to the steel, and it produces a negative charge on the steel. Since the steel must give up electrons in order to corrode, the negative charge prevents this from happening. (Electrons have a negative charge.) This is a better way of protecting steel from corrosion, since a valuable metal is not wasted in the protection as happens with the sacrificial anode.

Impressed Voltage



14. Why is impressed voltage cathodic protection preferable to a sacrificial anode for underground storage tanks?

_____

_____

_____

15. What problems do you think would be created if corrosion of underground storage tanks and pipelines was allowed to occur?

_____

_____

_____

_____

16. Why aren't storage tanks, pipelines, and ships tin-plated to protect the steel? (Hint: Think of how long tin cans last.)

_____

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 1: Enrichment.

Follow-up Activities

If you had difficulty understanding the concepts in the activities of this section, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

To help you master the concept of metallurgy, metals, alloys, and corrosion and its prevention, read the following information thoroughly. Complete the questions that follow.

- Metallurgy involves the production of metals.
- Smelting of minerals from their ores is used to produce metals such as iron and copper. Passing electricity through melted minerals produces metals such as aluminum.
- Alloys are made by mixing mixtures of two or more metals.
- Bronze is an alloy of copper and tin, and steel is an alloy of iron and carbon.
- Corrosion is the wearing away of a metal by chemical action.
- Corrosion of a metal is prevented by painting, plating with other metals, using a sacrificial anode, or using cathodic protection.

1. Which of the following metals is produced by smelting?

   A. iron
   B. copper
   C. gold
   D. aluminum

2. Which of the following metals was unknown to prehistoric people?

   A. vanadium
   B. gold
   C. lead
   D. copper

3. Bronze is an alloy that contains copper and

   A. zinc
   B. nickel
   C. silver
   D. tin

4. A metal made by combining two or more metals is called

   A. copper
   B. alloy
   C. corrosion
   D. steel

5. The purpose of plating chromium onto steel is to

   A. make it harder
   B. make it stronger
   C. make a dull metal attractive
   D. prevent corrosion

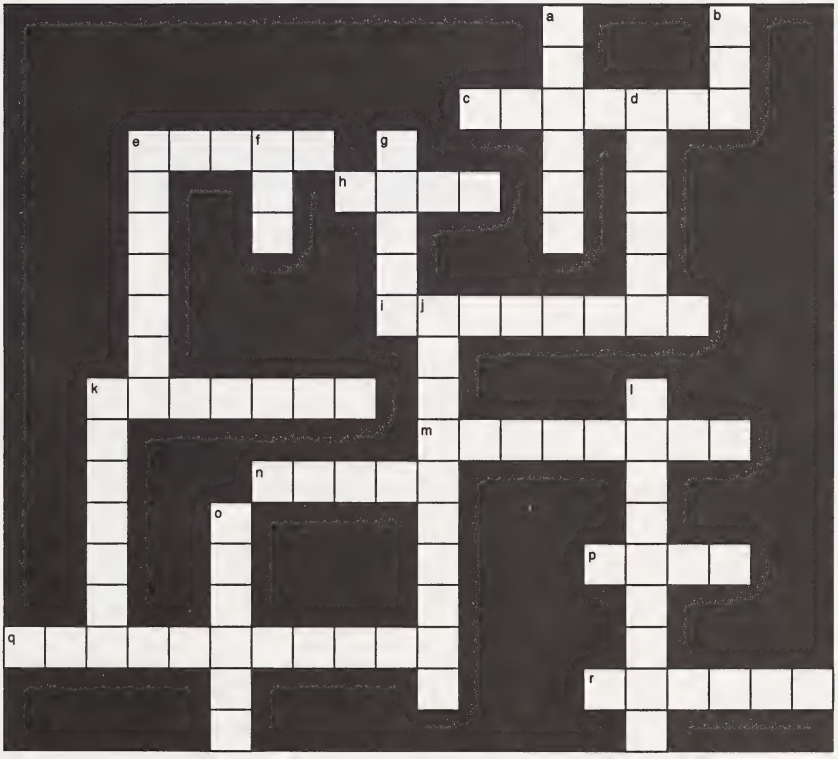
6. The alloy used by dentists for tooth fillings is

   A. bronze
   B. brass
   C. amalgam
   D. cementum

7. A mixture containing a metal compound and impurities is called

   A. an alloy
   B. an ore
   C. azurite
   D. bronze

8. Complete the following crossword on metallurgy.



Across

c. found in microchips
e. metal mixture
h. widely used metal
i. metal extraction using heat
k. liquid metal
m. ancient-known metal
h. iron alloy
p. precious metal
q. coating with zinc
r. early discovered metal

Down

a. joins metals
b. used in bronze
d. found in charcoal
e. copper mineral
f. contains minerals
g. copper and zinc alloy
j. metal extraction and processing
k. metal-containing compound
l. rust is a form of
o. copper and tin

Check your answers by turning to the Appendix, Section 2: Extra Help.

Enrichment

Do at least **one** of the following.

1. Alessandro Volta produced the first electric battery. He used layers of copper and zinc disks piled one on top of the other. Pads soaked in sea water were placed between the disks.

   Use outside reference sources to explain how Volta made his battery and why electricity was produced when two dissimilar metals and an electrolyte are used. A diagram may be helpful.

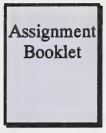
2. Smelting produces large amounts of sulphur dioxide gas. Sulphur dioxide dissolves in rain water to produce acid rain. Explain why industry's demand for inexpensive metals such as iron is ultimately responsible for acid rain.

Check your answers by turning to the Appendix, Section 2: Enrichment.

Conclusion

Metallurgy is the science and technology of metals. Smelting or electro-chemical extraction are two methods used to obtain metal. Once obtained, the metal can be made into useful products.

Corrosion of metal and its prevention is an important consideration when using metal material. Corrosion destroys the useful properties of a metal and is responsible for the high costs involved in repair and replacement of modern products.



ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 2.

3 Investigating Metals

NRC/IMC

Why isn't cookware made from lead? Why aren't pop cans made from copper? Why are so many objects made from iron? The key to these questions is that the properties of certain metals make the metals suitable for many applications. Although you use metal objects every day, you probably don't think about why each object is made from a particular metal.

In this section you will investiagate which metals have which properties. You will develop science-inquiry skills when you investigate the properties of metals. You will learn how to tell if a metal has certain properties. You will also learn why these properties are desirable in a metal.

Activity 1: What Is Lustre?

What is the most obvious difference between a brand new coin and one that is several years old? A new coin is shiny, while an old one is usually dull. Metals that are shiny are said to be lustrous.

Metals lose their lustre when the surface metal reacts with other substances. Two of the most common forms of corrosion result when oxygen and sulphur react with metals.

Tarnish

tarnish – a loss of lustre caused by a thin-coloured layer forming on an exposed metal surface

Have you ever had to remove the **tarnish** from silverware? New silverware has an attractive, brilliant shine. As the silverware sits in your house or is used for its intended purpose, it loses some of that shine and may even turn black and look ugly. What happened? Can it be fixed?

Silver tarnishes because sulphur reacts with silver to produce silver sulphide, (Ag_2S), a dark-coloured, unattractive compound. Where did the sulphur come from? It came mainly from two sulphur compounds found in the air, sulphur dioxide and hydrogen sulphide.

1. What is meant when an object is said to be lustrous?

   _____

   _____

2. Why does copper lose its lustre?

   _____

   _____

3. Why would some people dislike owning silverware?

   _____

   _____

4. What is the black film that develops over time on silverware called? Where does it come from?

_____

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 1.

How can the tarnish on silverware be removed? Scrubbing it off with a rough polish is one way, but some silver is lost because the tarnish is a silver compound, Ag_2S. There is a better way to do this by using chemistry. This next investigation will show you how it's done.

Investigation: Lustre

In this investigation you are going to restore the lustre of tarnished silverware without using polish. The silverware will not be damaged in any way.

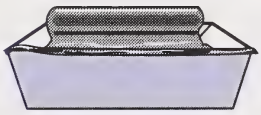
Materials You Need

- sample of tarnished silverware or silver-plated object
- large plastic container (such as an ice cream pail or dish pan)
- aluminum foil
- 125 mL washing soda (Na_2CO_3), baking soda ($NaHCO_3$), or a water softener solution
- hot tap water
- stopwatch or a clock or watch which measures seconds

Steps to Follow

STEP A

Line the bottom and inner sides of a plastic container with two or three layers of aluminum foil. Fill the lined container 3/4 full of hot water.

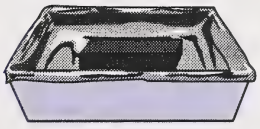


STEP B

Add about 125 mL of the soda to the hot water. Mix the solution.

STEP C

Place the tarnished object completely into the solution. Make sure that the object touches the bottom layer of aluminum foil. If the object is large and part of it is exposed above the solution, repeat the process after several minutes. (Make sure the exposed parts are turned so they touch the foil.)



STEP D

Keep the tarnished object in the solution for several minutes until the tarnish disappears. Record your observations every thirty seconds in the observation table.

Observations

5. Record your answers in the observation table.

Time in Thirty-second Intervals	Observations
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

6. How long did it take for the tarnish to begin disappearing?

_____

7. How long did it take for the tarnish to disappear completely?

_____

8. Describe the appearance of the aluminum foil before the investigation.

_____

_____

9. Describe the appearance of the aluminum foil at the end of the investigation.

_____

_____

Conclusion

10. What do you think happened to the tarnish? How?

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 1.

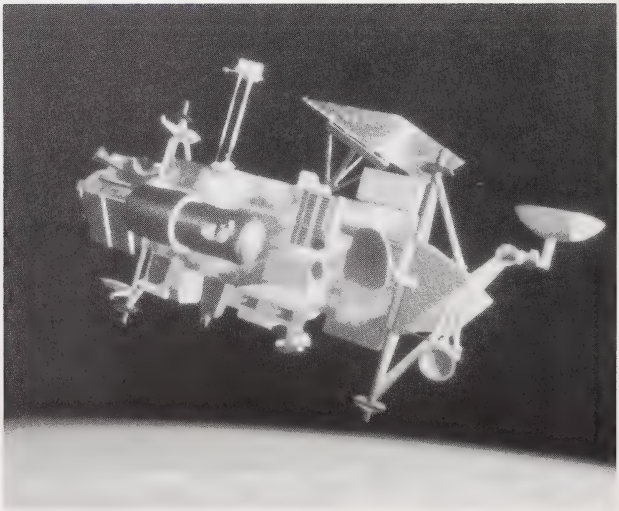
Activity 2: What Is Conductivity?

What metal is used to make household electrical wiring? Is the same metal used for power lines?

conductor – a substance that allows electricity or heat to flow through it

Some metals are better **conductors** of electricity than others.

Gold, platinum, and silver are good conductors. However, they are only used in special or intricate electric circuits such as computers and satellites.



NASA

1. Why do you think the use of gold, platinum, and silver as conductors is restricted to special circuits only?

Copper and aluminum are good conductors, though they not as good as silver. Copper is the most widely used conductor for electricity because it is ductile, relatively inexpensive, relatively resistant to corrosion, and a good conductor. Iron and steel are not used in wiring and power lines because they are much poorer conductors than copper is. Aluminum is not used much in wiring because it is too soft and causes problems when used improperly with copper wiring.

2. Why isn't iron used for household electrical wiring?

3. Aluminum is almost as good a conductor as copper. Suggest a reason why copper is used in electrical wiring and power lines more than aluminum is used.

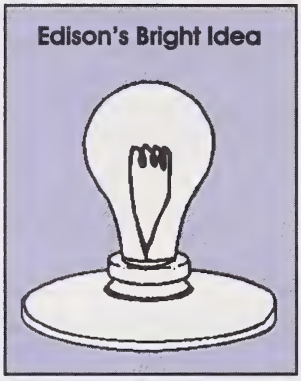
resistance – the property that determines how much electricity will flow

When a metal has a high **resistance** it is said to be a poor conductor. The resistance of an object depends on the following characteristics.

- Composition: Some metals have less resistance than others.
- Thickness of object: A thin wire has more resistance than a thick wire of the same material.
- Length of object: A long wire has more resistance than a short wire of the same material.
- Temperature: The higher the temperature, the higher the resistance.

Look inside an unfrosted light bulb (when it's not on). What do you see? You should notice a very thin coiled wire. The wire is probably made of tungsten, which is a good conductor. The resistance of the wire is high because the wire is very thin. When electricity passes through the wire, the high resistance causes it to get white hot. This white hot wire produces the light. If iron or steel was used as the **filament** of the light bulb, it would melt very quickly and cause the bulb to burn out.

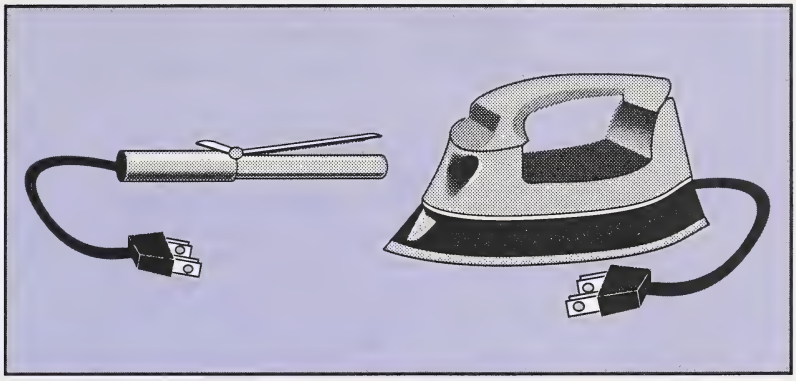
filament – a thin wire or thread with high resistance to the flow of electricity



4. If the filament of a bulb is made of steel, it would melt. What can you say about the melting point of tungsten?

5. Edison's original light bulb used a carbon filament. These bulbs lasted a very long time before they would burn out. Can you think of some reasons why the modern light bulbs are made with a tungsten filament when they seem to burn out so quickly?

Electric irons, toasters, stoves, curling irons, and kettles all have a common principle at work. Electricity passes through a conductor with high resistance. This causes the conductor to get hot enough to do a particular job. The wire in an electric toaster is a Nichrome wire. It is very thin and gets red hot very quickly so that your bread is toasted. The elements on your stove can hold a range of temperatures as more or less current is allowed to flow through. The curling iron and electric iron can be adjusted to produce just the right amount of heat needed for curling or ironing without burning.



6. What two metals do you think are used to make the Nichrome alloy?

_____

7. Why do you think the element of a stove isn't made of copper?

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 2.

Investigation: Conductivity

In this investigation you will test the conductivity of metals. If you have access to a conductivity meter, go directly to Part B. If you do not have access to a conductivity meter, do Part A and then Part B.

Part A

In Part A you will build your own conductivity tester.

Materials You Need

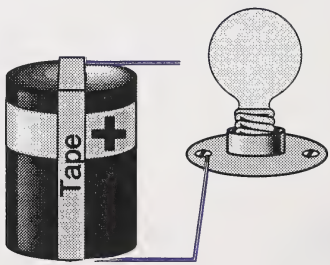
- flashlight battery
- bulb socket
- bulb (1.2 V – 1.5 V)
- 3 30-cm lengths of insulated copper wire
- steel wool
- electrical or transparent tape

STEP A

Use tape to connect two wires to the battery as shown in the diagram. Make sure the bare part of the one wire is touching the + terminal and the bare part of the other wire is touching the – terminal.

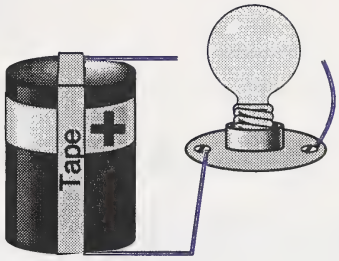
STEP B

Connect the wire from the – terminal to one of the bulb holder terminals by slipping the bare end of the wire under the screw and then tightening the screw.



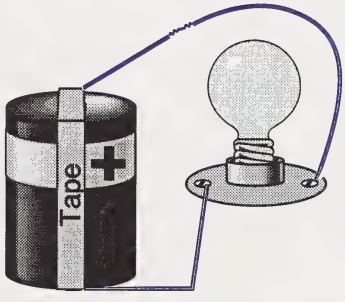
STEP C

Connect the third wire to the other bulb holder terminal by tightening the screw.



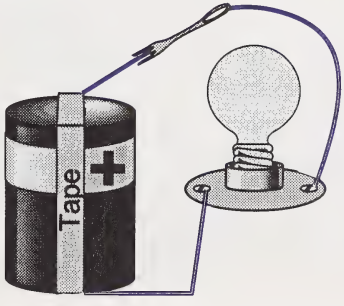
STEP D

Test your conductivity tester by touching the two loose ends of wire together as shown in the diagram. The bulb must light up. If it doesn't, check the connections, the bulb, and the battery.



STEP E

To use your conductivity tester simply touch the loose wire ends to the ends of any object you wish to test. Here a fork is being tested. It conducts electricity!



Part B

Try to obtain or have access to as many of the test items as you can for your collection. (Try to include at least one item from each metal and nonmetal group.) Other suitable items not listed here can also be used.

Materials You Need

- conductivity tester

Metal	Suggested Test Item
Aluminum (Al)	pop can, aluminum, foil, aluminum wire, cooking pot or pan, foil cookware
Lead (Pb)	lead fish line sinker, lead shot, solder, car battery posts
Zinc (Zn)	dead flashlight battery container with plastic cover removed, galvanized sheet metal, garbage can, or furnace pipe, electrical outlet box
Iron (Fe)	coat hanger, bolt or nail, steel wool, stainless steel cutlery, paper clip, barbed wire
Copper (Cu)	copper wire, brass key, household water pipe
Tin (Sn)	tin can, solder, pewter ware
Silver (Ag)	silverware, jewellery (bracelet, earring), nickel, dime, or quarter dated before 1968
Nickel (Ni)	nickel, dime, or quarter dated after 1968, alnico magnet
Chromium (Cr)	water faucet, water closet tube (tube from toilet tank to water supply), car bumper

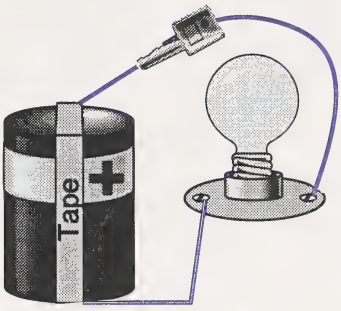
Nonmetal	Suggested Test Item
Carbon (C)	pencil lead, charcoal briquette, carbon paper, typing ribbon, graphite
Wood	paper, cardboard box, desk top, pencil, piece of lumber or plywood
Plastic	margarine, sour cream, or cottage cheese container, plastic cutlery, cassette or CD case, plastic grocery or shopping bag, plastic pop bottle
Glass	window, jar, pop bottle, light bulb

Steps to Follow

STEP A

Test each of the materials in your collection to see if they conduct electricity by holding the wire leads on each end of the chosen item.

Record your results in the table.



This key is a conductor!

Observations

8. Record your results in the observation table.

Metal	Object	Conductivity
Aluminum (Al)		
Lead (Pb)		
Zinc (Zn)		
Iron (Fe)		

Metal	Object	Conductivity
Copper (Cu)		
Tin (Sn)		
Silver (Ag)		
Nickel (Ni)		
Chromium (Cr)		

Nonmetal	Object	Conductivity
Carbon (C)		
Wood		

Nonmetal	Object	Conductivity
Plastic	_____ _____	_____ _____
Glass	_____ _____	_____ _____

Conclusions

9. What generalization or conclusion can be made about the conductivity of metal objects?

_____

_____

10. How do metal alloys behave compared to pure metals?

_____

_____

11. What generalization or conclusion can be made about the conductivity of nonmetal objects?

_____

_____

12. Which nonmetals conduct electricity?

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 2.

Activity 3: Which Metals Are Magnetic?

Does your can opener have a magnet to lift an opened lid?

Is your fridge covered with memos, newspaper clippings, and other reminders? Are they stuck on with magnetic holders?

Have you ever seen a huge electromagnet on a crane lift scrap metal to railroad cars or trucks?

Magnetic properties of some metals make them useful in making microphones, stereo loudspeakers, and recording tapes.

1. Suggest other things that depend on the use of magnets.

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 3.

Investigation: Magnetism

You will use a magnet to test which materials have magnetic properties.

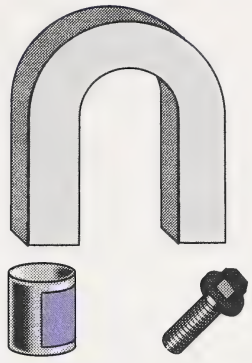
Materials You Need

- one magnet
- your collection of metal objects used in the previous investigation

Steps to Follow

STEP A

Test each of the items in your collection for magnetic properties by bringing the magnet closer to the object until the magnet touches the object. If the object is attracted to the magnet in any way, the object is magnetic. Record your observations in the table.



Observations

2. Record your results in the table.

Metal	Object	Magnetism
Aluminum (Al)		
Lead (Pb)		
Zinc (Zn)		
Iron (Fe)		

Metal	Object	Magnetism
Copper (Cu)		
Tin (Sn)		
Silver (Ag)		
Nickel (Ni)		
Chromium (Cr)		

Nonmetal	Object	Magnetism
Carbon (C)		
Wood		

Nonmetal	Object	Magnetism
Plastic	_____ _____	_____ _____
Glass	_____ _____	_____ _____

3. Which materials are magnetic?

_____

_____

Conclusions

4. What generalization or conclusion can be made about the magnetic properties of materials?

_____

_____

_____

_____

5. How are Fe, Ni, and Co arranged on the periodic table?

_____

_____

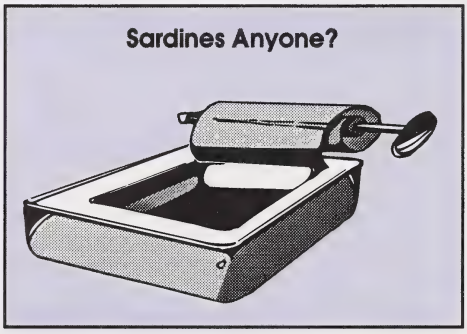
Check your answers by turning to the Appendix, Section 3: Activity 3.

Activity 4: Malleability and Ductility

Gold and silver were metals of choice for making jewellery. Not only were they shiny metals, but they were easy to hammer and bend into desired shapes without breaking. Gold can be hammered into such thin sheets that they become almost see-through. A single ounce of gold (38 g) can be hammered into a sheet large enough to cover the floor of an average classroom. Other materials tend to break and crack when one tries to hammer them into a particular shape. Gold and silver are said to be **malleable**.

malleable – capable of being hammered or changed into a desired shape without breaking

How can you test a metal to see if it is malleable? You can hammer it to see if it will change shape without breaking. An easier way is to bend the metal. If you can bend it into a new shape without breaking it, it is malleable.



Is this can of sardines made of a malleable metal? Yes, you can see where the lid was bent into a new shape as the key was turned.

[1]

Railroad track is made of steel. Is railroad track made of a malleable metal? Yes, the photograph clearly shows the tracks bent into odd shapes. The tracks were bent because of the expansion of steel in very hot weather.

1. Suppose you are given a spoon which looks like metal but feels much too light. How could you test the spoon to see if it was made from a metal?

_____

_____

_____

_____

[1] *The Edmonton Journal* for the photograph by Brian Gavriloff taken from July 12, 1990, p.1 issue. Reprinted with permission of *The Edmonton Journal*.

2. Imagine a person produced a new alloy which was both very light and very malleable. Explain why this alloy would not be suitable for making airplanes.

3. For each object, tell whether you think it is made of a malleable material. Explain your answer.

   a. car

   b. pop can

   c. pencil

   d. kitchen knife

   e. coat hanger

Investigation: Malleability

In this investigation you will test the malleability of the objects in your collection.

Materials You Need

- your collection of objects used in the previous investigations (Do not use glass objects in this investigation.)

Steps to Follow

STEP A

Try to bend each of the objects from your collection. **Do not** try to bend any glass object. **Do not** use too much force because some objects will break if bent too far. As soon as you feel the object is bending, release it.

Observations

4. Record your results in the following table.

Metal	Object	Malleability
Aluminum (Al)		
Lead (Pb)		
Zinc (Zn)		
Iron (Fe)		
Copper (Cu)		
Tin (Sn)		
Silver (Ag)		
Nickel (Ni)		
Chromium (Cr)		

Nonmetal	Object	Malleability
Carbon (C)	_____ _____	_____ _____
Wood	_____ _____	_____ _____
Plastic	_____ _____	_____ _____

5. Which metals are malleable?

_____

_____

6. Were any nonmetals malleable? Explain.

_____

_____

_____

Conclusions

7. What generalization can you make about the malleability of metals and nonmetals?

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 4.

Do you know how wire is made? A metal is drawn through a series of progressively smaller holes until a wire of required diameter is produced. The actual process may be more complex involving rollers and heat, but the wire is still drawn out through holes. A metal which can be drawn into wire is said to be **ductile**.

ductile – ability to be drawn into wire through a small hole

Ductility is usually related to malleability. In general, the more malleable a metal, the more ductile it is.

8. What generalization can you make about the ductility of metals and nonmetals?

_____

_____

9. Gold is very ductile. Gold is not used for making electrical power lines because it is a very rare metal. Suggest another reason why gold is not used for electrical power lines.

_____

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 4.

Follow-up Activities

If you had difficulty understanding the concepts in the activities of this section, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

To help you master the concept of metal properties, read the following information thoroughly. Complete the questions that follow the information.

- Metal properties can be obtained from scientific inquiry through investigation.
- Metals are lustrous or shiny.
- Metals are good conductors of electricity and heat.
- Iron, nickel, and cobalt metals are magnetic.
- Metals are ductile or can be bent.
- Metals are malleable or can be stretched or hammered into a desired shape.

1. Fill in the blanks.

   a. Metals that are shiny are said to be _____.

   b. A shiny metal is _____, which is plated over other metals.

   c. _____ metal is a good conductor of heat and is used to make pots and pans.

   d. _____ metal is a good conductor of electricity and is used for household wiring.

   e. Metals that are attracted to magnets are _____, nickel, or cobalt.

   f. Metals bend or are said to be _____.

2. Match the terms on the right with the phrases on the left by placing the appropriate letter of the term in the blank beside the phrase.

_____	i.	easily tarnished	a. Cu
_____	ii.	light-bulb filament	b. ductile
_____	iii.	heavy metal used for car batteries	c. Al
_____	iv.	good conductor of electricity	d. tungsten
_____	v.	attracted to a magnet	e. Ag
_____	vi.	common metal used to conduct electricity in houses	f. malleable
_____	vii.	can be stretched into wire	g. Pb
_____	ix.	electricity can flow through	h. conduct
_____	x.	can be bent	i. Fe

Check your answers by turning to the Appendix, Section 3: Extra Help.

Enrichment

Do one of the following questions.

1. Discuss which metals and their properties would make them suitable for making cars. Use examples of the car parts involved.

2. Modern technology has begun to use the properties of metals to advance products even further. For example, some eyewear companies have began to use certain metals with the influence of technology so that the metal eyewear frames retain the shape of the wearer.

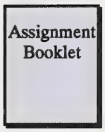
   a. What property would metals need to have in order to produce a product such as this?

   b. How can doing this to eyewear be beneficial?

   c. Give a disavantage of using technology on eyewear to this extent.

Conclusion

Metals possess unique properties such as lustre, conductivity, malleability, and ductility. These properties make the use of metals advantageous in advancing technology because useful products can be made.



ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 3.

4 Using Metals

PHOTO SEARCH LTD.

If you look at this photo, you probably don't recognize many metal aspects immediately. However, metals play a large role in this photo even though you may not detect the metals right away. Metals were used in the production of the clothes the student is wearing. Metals were used in the production of the furniture. Metals were used in the production of the books the student is using, and metals were actually used in producing the photo. As you can see, metals do play a major role in many aspects of your life even though the metals may not be obvious.

In this section you will learn how metals are used. You will learn why certain metals are used for certain applications. You will also learn about the benefits and hazards of using metals.

Activity 1: What Are Uses of Common Metals?

Why does a building engineer select iron, aluminum, or copper for a new building? Which metals are used for making the cutlery you eat with?

There are a number of factors to take into consideration when selecting a metal for a specific use. Cost, properties, and human health are some important considerations you will assess while deciding which metals are most useful in certain applications.

Iron Applications

Which metal is used to make cars, railway tracks, farm machinery, and oil drums?

Look at the products in the pictures. What are most of the things made of? You can readily see that iron is a widely used metal in the world.

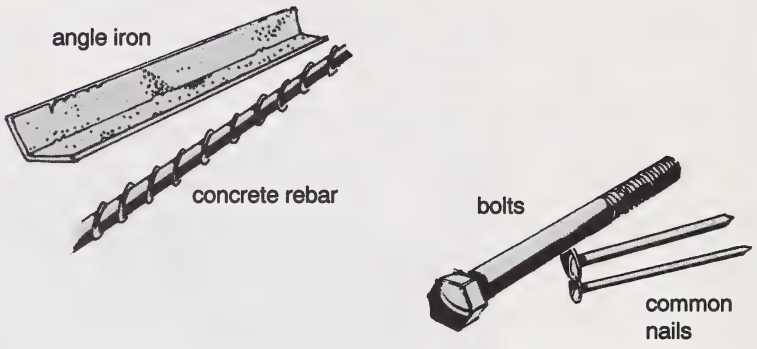
WESTFILE INC.

WESTFILE INC.

1. Why do you think iron is used so extensively?

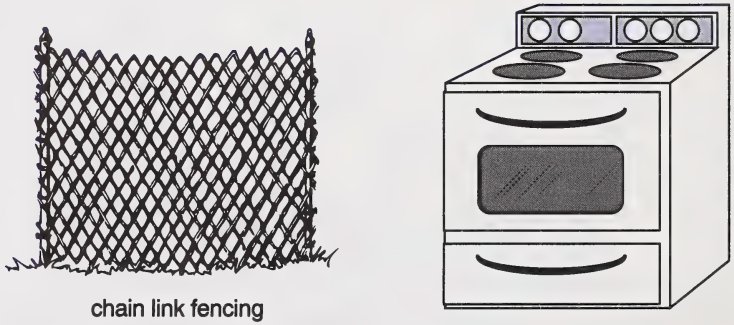
Iron is usually alloyed with varying amounts of carbon, nickel, chromium, tungsten, and other substances to produce the alloy steel. The properties of steel, such as hardness, melting point, and corrosion resistance, vary depending on the kinds and amounts of alloying substances added. In general, the terms *steel* and *iron* are used interchangeably unless the alloy is very different from iron. An example is stainless steel which is not called iron. Other common iron and steel applications along with their properties are shown next.

A. Iron



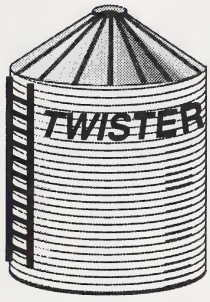
Angle iron, reinforcing rods and wire, bolts and nails, and cast iron are made from relatively pure iron. These items will rust very quickly in moist air thus producing iron (III) oxide trihydrate, ($Fe_2O_3 \cdot 3\ H_2O$).

B. Coated Iron and Steel

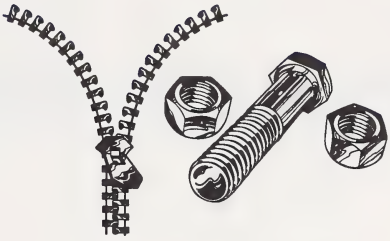


Appliances, cars, farm machinery, and exposed building steel are often painted to reduce corrosion. Plastic coating is used for residential chain link fencing.

C. Plated Steel



grain bin

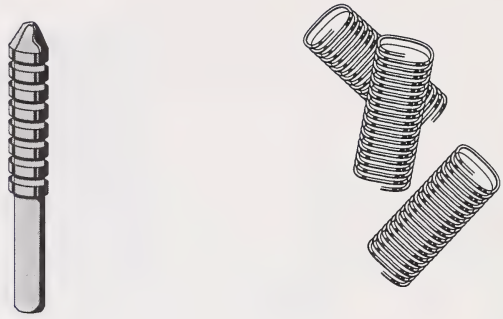


Steel products which are exposed to outside elements, like grain bins and barbed wire, are often galvanized by dipping them into molten zinc or electroplating them with zinc. Steel products which need to be shiny and corrosion resistant, like car bumpers, are plated with chrome.

D. Stainless Steel

Stainless steels are very corrosion resistant. Stainless steel is an alloy of iron, chromium, and possibly other elements such as nickel and silicon. Cutlery, sharp knives, chimneys, and automobile exhaust pipes are but a few uses for stainless steel.

E. Special Steels



Alloys which have been heat treated are used to produce an incredible variety of steels. There are very hard steels used for drill bits, chisels, and concrete nails. These hard steels tend to be brittle. There are steels used to make springs which are necessary in every automobile and home.

2. Using the five previous iron applications, identify to which application each of the following objects belong. The first one is done for you.

   a. barbed wire fencing *C. Plated Steel*

   b. dental and surgical instruments _____

   c. metal outdoor garbage can _____

   d. drill bit _____

   e. metal scouring pad _____

   f. furnace heat duct _____

   g. railroad tracks _____

   h. metal paint can _____

   i. metal water trough for livestock _____

j. construction I-beams _____

k. car frame _____

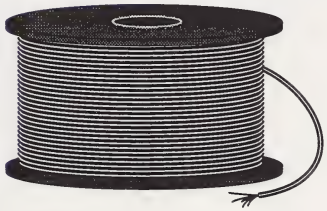
l. spring used to close a door _____

Check your answers by turning to the Appendix, Section 4: Activity 1.

Copper Applications

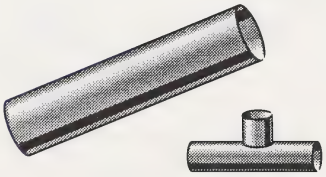
Copper lacks the strength of iron, but it is more corrosion resistant and is a much better conductor. Next to iron it is the second most widely used metal. Some of the applications of copper are shown.

Electrical Wiring



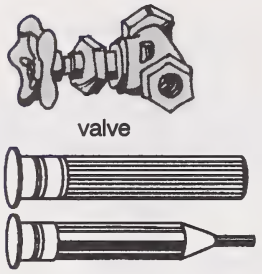
Copper is the second-best electrical conductor next to silver. Copper is used extensively in wiring, electric motors, and all types of electrical applications.

Copper Pipes and Fittings



Copper pipes and fittings are widely used in plumbing, air conditioners, and radiators.

Brass Uses



Brass is an alloy containing 60% copper and 40% zinc. Brass valves are used in plumbing.

Brazing Alloy

Brazing alloy contains 57% copper, 42% zinc, and 1% tin. A brazing rod melts and solders metals together. The flux on the rod cleans the metal surface during the process.

3. Suggest where copper is used in electric motors.

_____

_____

4. Why is copper rather than iron used in plumbing?

_____

_____

5. List some other common objects made from brass.

_____

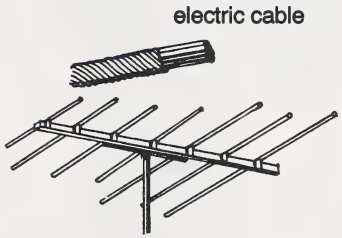
_____

Check your answers by turning to the Appendix, Section 4: Activity 1.

Aluminum Applications

Does your house have aluminum siding, soffits, eavestroughing, windows, or doors? Aluminum is the third most widely used metal. The following are examples of aluminum applications.

Electrical Uses



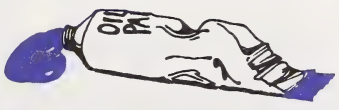
The electrical conductivity of aluminum is about 60% that of copper. Its light weight makes it an ideal metal application.

Aircraft Aluminum

jet airliner

Aircrafts are made from an aluminum and magnesium alloy. Its strength, light weight, and low cost is an advantage to its use.

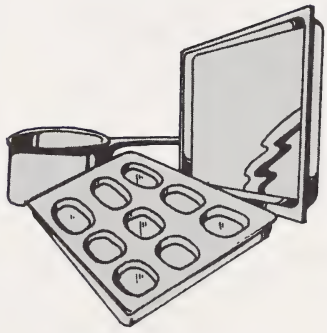
Collapsible Tubing



paint tube

Tubes packaged with toothpaste, glue, paints, lotions, and ointments are convenient dispensers.

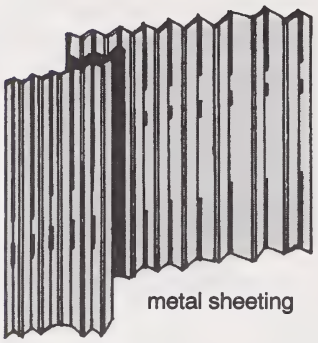
Cookware



cooking pans and pots

Aluminum is light, corrosive resistant, and a good conductor of heat. It is extensively used for cookware, bakeware, and foil wrap.

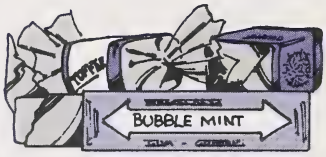
Building Material



metal sheeting

Aluminum siding, soffits, and eavestroughing are common maintenance-free home building materials. The surface is protected by paint, lacquer, or enamel.

Foil



foil gum wrapper

Aluminum foil is used often as a product wrapper. Coloured foil can also be made and used when an attractive appearance is desired.

6. Why do you think aluminum foil is sometimes called tinfoil in error?

_____

_____

7. Copper and aluminum are both good conductors of heat. Suggest why copper cooking utensils are not as common as those made of aluminum.

_____

_____

8. What properties of aluminum make it a desirable metal for many applications?

_____

_____

_____

Check your answers by turning to the Appendix, Section 4: Activity 1.

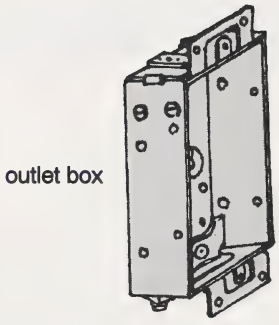
Zinc Applications

Zinc is one of the most widely used metals. It is often used to make galvanized steel and metal alloys. Canada is the leading producer of zinc, constituting 23% of the world's production. Some common zinc applications are shown next.

Dry Cell Container

A zinc can contains dry chemicals that react with the zinc to produce electricity. The zinc can is covered with paper and a steel jacket. People commonly recognize this zinc can as a battery.

Electrical Materials

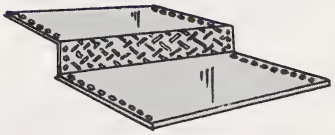


Galvanized steel is used for a variety of electrical outlet boxes, connectors, clamps, staples, conduit pipes, and other essentials.

Plumbing Fittings

Galvanized steel pipes and fittings are used in plumbing.

Towers



Structural steel, which is exposed to the elements, is often galvanized.

9. Suggest some common uses for galvanized sheet metal.

_____

_____

10. Why is galvanized sheet metal generally not used to make cookie sheets and other bakeware?

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 4: Activity 1.

Lead Applications

Lead and its compounds are highly poisonous. Some historians have suggested that lead poisoning was partially responsible for the decline of the Roman Empire when lead was extensively used for water pipes and pewterware.

Lead is one of the heavy metals. In modern times, lead is used in combination to make everyday items like solder, batteries, pipes, and crystal glass.

Did You Know?

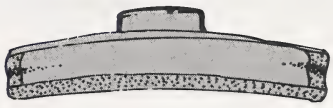
The symbol for lead is Pb. It comes from the Latin word for lead, *plumbum*. A lead worker was a plumber.

Some common lead applications are shown.

Solder

An alloy containing 40% lead and 60% tin is 40-60 solder. Metals can be joined together by the melting and solidification of solder.

Tire Balance Weights

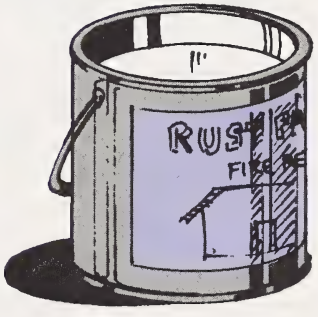


Lead is a very soft and dense metal. It is ideal as a counterweight in balancing car tires.

Lead Battery

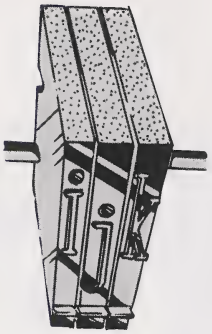
Lead is used to make battery plates. Alternating plates contain lead (IV) oxide (PbO_2). The plates are dipped in sulfuric acid and a reaction produces electricity.

Lead Paint



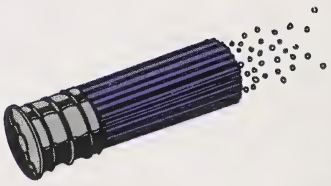
A compound called lead (II) sulphate ($PbSO_4$) is used as a white paint lead pigment. Red paint pigment is Pb_3O_4 and chrome yellow is $PbCrO_4$.

Metal Type



Hot lead is rapidly molded into letters and words for printing needs such as newspapers. The lead type can be melted and reused for other printing needs. This printing technology is rarely used as it has been replaced by quicker, inexpensive printing technologies.

Lead Shot



Lead pellets are expelled from shotgun shells when the gunpowder explodes. Lead shot is being replaced by steel shot. Lead is a toxic element and should be eliminated from the environment whenever possible.

11. Suggest why environmentalists demanded an end to the use of lead compounds in gasoline.

_____

_____

_____

_____

12. Why are lead-based paints no longer allowed on pencils and baby furniture?

_____

_____

_____

13. List some examples where lead solder is used.

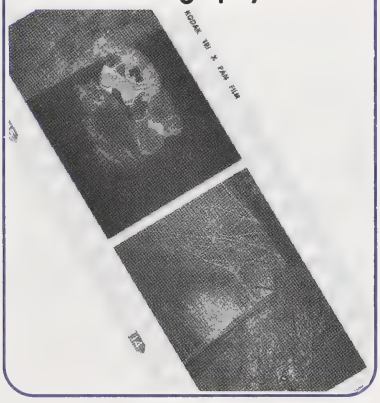
_____

_____

Check your answers by turning to the Appendix, Section 4: Activity 1.

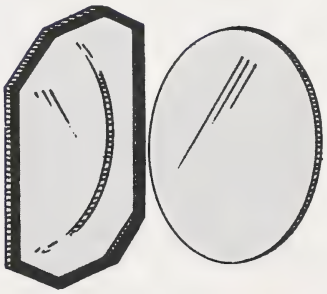
Silver Applications

Photography



North America uses about one-third of its industrial silver in the photographic industry. Black portions on a negative are exposed silver.

Mirror



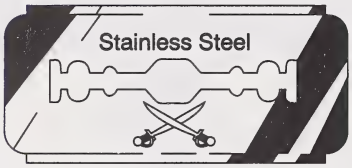
Pure silver is the best known reflector of light.

Did You Know?

A compound called silver iodide (AgI) is used for seeding clouds to produce rain.

Other Metal Applications

Stainless Steel



razor blade

A stainless steel alloy contains iron, chromium, and nickel in varying amounts. It is used to make stainless steel kitchen utensils, sinks, and surgical instruments.

Coins

Since 1968, Canadian coins are made from nickel. Prior to 1968 they were made from silver.

14. Why do you think iron, copper, and aluminum are used to make more objects than other metals?

_____

_____

_____

15. Nickel coins replaced silver coins in 1968. Why?

_____

_____

Check your answers by turning to the Appendix, Section 4: Activity 1.

Activity 2: Metal Waste Management

What do you do with things when they break or wear out beyond repair? You throw them out right? What happens to those things you throw out? Garbage has to go someplace.

Metal wastes are responsible for a special waste disposal problem. Some metals are harmful to living things, and if disposed of incorrectly, can leach into water supplies.

Metal Garbage

Not that long ago plastic pop bottles and metal pop and beer cans were discarded along with regular garbage. Some provinces still don't have a collection system to stop this practice. However, in Alberta these containers are not thrown away. Instead, a small deposit is part of the purchase price of the pop or beer and it is refunded when the containers are taken to a bottle depot. For example, the aluminum metal in the cans is **recycled** at a recycling plant saving almost 95% of the energy needed to produce aluminum from its ore.

recycle – to make new products from discarded products

What about all of the other metals you use in products such as appliances, vehicles, canned foods, and batteries? Are these metals recycled or are they thrown out along with regular household garbage? Your town or city might have a collection system to pick up metals for recycling. The majority of metals are still taken to landfills. A landfill is a waste disposal system where solid wastes are layered with soil in a natural or excavated depression. Waste and soil are packed, and the process is repeated until the depression is filled.

1. Suggest some problems you can see arising from the promotion of a metal recycling program.

   _____

   _____

   _____

   _____

2. Do you think recycling waste metal is better than disposing of it in a landfill? Why?

   _____

   _____

3. Do you think there are any metals which cannot be recycled?

Check your answers by turning to the Appendix, Section 4: Activity 2.

Special Wastes

Special wastes, such as toxic materials, chemicals, paints, pesticides, and a variety of household products, must be stored in a particular way. Metals are used to make containers to safely store these materials. For example, metal is used to make large transformers containing PCBs.

When the containers are filled, these wastes are shipped to a special kind of landfill site. At these landfill sites, such as the Alberta Special Waste Treatment Centre in Swan Hills, the wastes are removed from the containers, treated, and safely disposed. Because the containers are contaminated, they are shredded and disposed of in specially designed and secure landfills.

4. Household and industries both produce dangerous metal wastes, but industrial sources produce more such wastes. Why do you think this is so?

5. What processes are involved in disposing of toxic metals?

Check your answers by turning to the Appendix, Section 4: Activity 2.

Follow-up Activities

If you had difficulty understanding the concepts in the activities of this section, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

To help you master the concept of metal uses or applications and metal waste management, read the following information thoroughly. Complete the questions that follow.

- Iron, steel, and galvanized steel are used to make major household appliances, farm machinery, and many other items.
- Copper and brass are used for household electrical wiring and plumbing requirements.
- Aluminum is used for household building materials, aircraft construction, cooking utensils, and foil.
- Zinc is used for making dry cells and galvanized steel products.
- Lead is used in making solder, lead-acid car batteries, and paint pigment.
- Unwanted metal products should be recycled or disposed of properly.

1. Suggest which metals or metal alloys are used to make the following products.

   a. paper clips _____

   b. grain storage bin _____

   c. TV antenna _____

   d. household electrical wire _____

   e. electric frying pan _____

   f. furnace pipes or ducts _____

   g. household hot and cold water pipes _____

   h. galvanized sheet metal _____

i. barbed wire _____

j. car battery posts _____

k. photographs _____

l. farm machinery shed _____

2. Place a T in front of the statements that are true and an F for those that are false. Correct any false statements.

_____ a. Iron is the most widely used metal.

_____

_____ b. Lead and its compounds are poisonous.

_____

_____ c. Zinc has a very high melting point.

_____

_____ d. Used oil cans can be recycled.

_____

_____ e. The Alberta Special Waste Treatment Centre in Swan Hills accepts used cars for disposal.

_____

_____ f. PCB-contaminated transformers are disposed in municipal landfills.

_____

_____ g. Lead is a good conductor.

_____

_____ h. Copper is a good conductor of heat and electricity.

_____

_____ i. Tinfoil is the common name for aluminum foil.

_____

_____ j. Aluminum foil always has a silver shine.

_____

Check your answers by turning to the Appendix, Section 4: Extra Help.

Enrichment

Do one of the following questions.

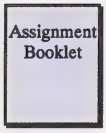
1. Use outside resources to obtain information on gold panning. Discuss how gold is panned.

2. Research the Alberta Special Waste Treatment Centre in Swan Hills, Alberta to find out more about what it does.

Check your answers by turning to the Appendix, Section 4: Enrichment.

Conclusion

Modern technology developed solely because of metals. While plastics have replaced metals in a few areas, modern society still heavily relies on metals. Everywhere you look you can see metals being used to improve the standard of living. While careless use and disposal of certain metals have harmed the environment, people are learning to reduce the use of harmful metals and to recycle useful metals.



ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 4.

MODULE SUMMARY

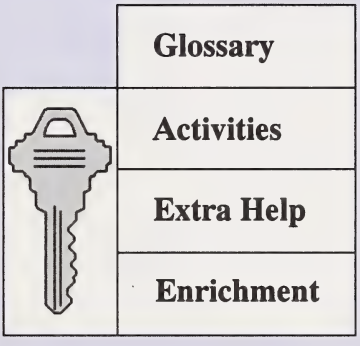
Technology uses a wide variety of materials to make products that everyone uses.

Material applications can involve something as simple as a pencil, wheelbarrow, or nail, but it can also involve something as complex as a space shuttle, VCR, personal computer, or artificial satellite.

Metals have and will continue to play an important role in the development of civilization. From the Bronze Age to the Iron Age to the present time, people have depended on metal. Transportation and communication devices, household appliances, kitchen utensils, building structures, and farming equipment are just a few examples of how modern society depends on metal applications.

Technology continues to develop the science of metallurgy and metal applications in the modern world. The interaction of science and technology in the research development and production of metal materials is important to modern civilization. Investigation of metal properties should develop an appreciation for the relationship of metal properties to their application.

Appendix



Glossary

alloy
- a mixture of two or more elements that have metallic properties

analogy
- an easier and more concrete visual picture explaining something abstract

bronze
- alloy containing the metals copper and tin

Bronze Age
- the period from about 3000 BC and earlier during which bronze was used to make weapons and tools

chemical change
- any change where a new substance is formed or the form of matter is different from the original

conductor
- a substance that allows electricity or heat to flow through it

control
- a standard to which experimental results may be compared

ductile
- ability to be drawn into wire through a small hole

element
- a substance containing only one kind of atom

filament
- thin metal wire with high resistance to the flow of electricity

galvanized
- steel coated with zinc metal to prevent it from rusting

heterogeneous
- a substance containing a mixture of several materials

homogeneous
- a substance that appears to be the same throughout

kinetic energy
- energy due to motion
  Examples include wind, a flowing river, a moving vehicle, or a baseball in flight.

malleable
- capable of being hammered or changed into a desired shape without breaking

matter
- any material that has mass and occupies space

metallurgy
- the science of extracting metals from naturally occurring ores or minerals and changing them into useful products

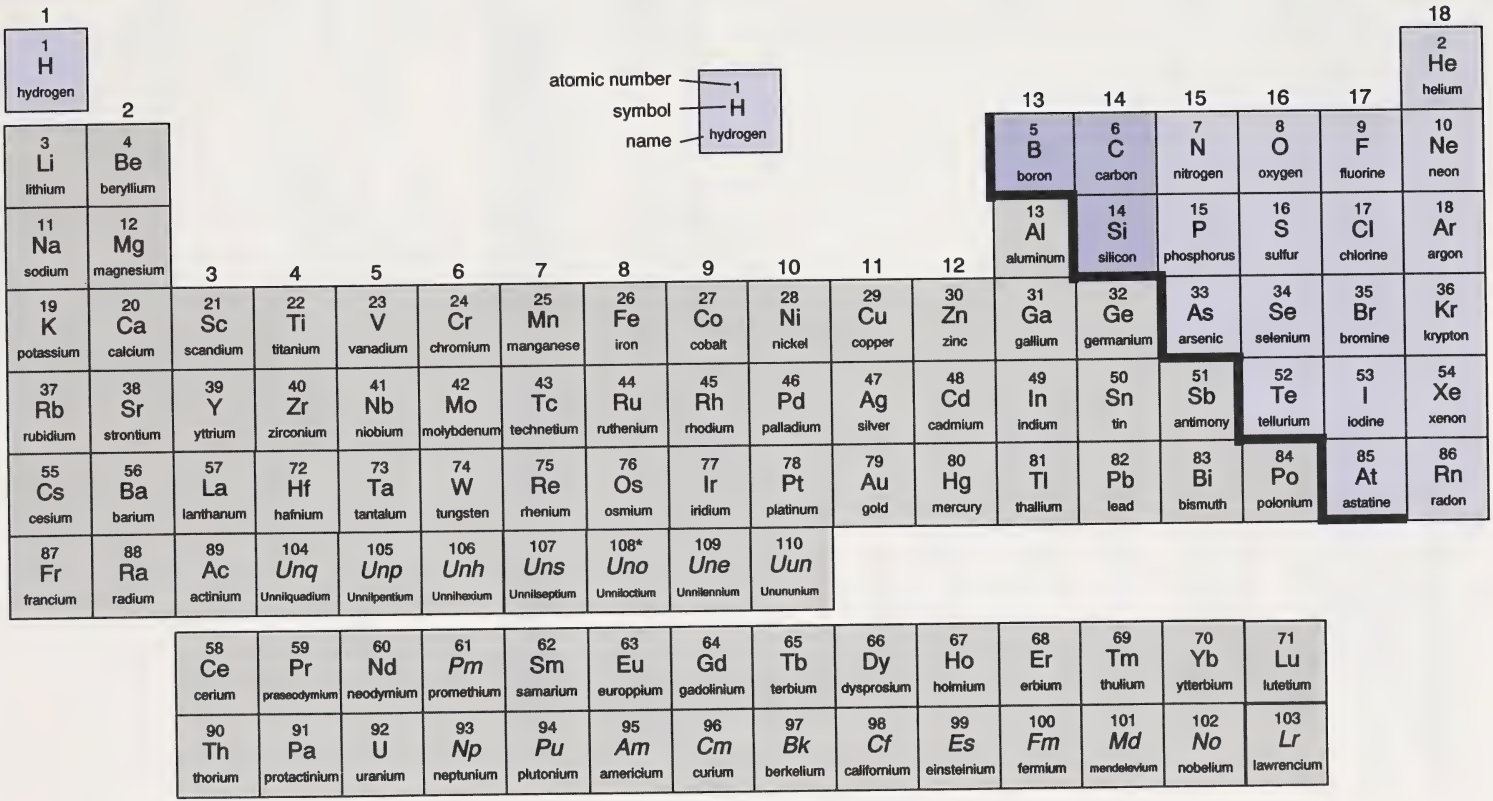
mineral
- naturally occurring compound that contains a specific metal

model
- a three-dimensional representation of a something

ore
- mixture of rock material and metal containing mineral

oxidation	• the action in which a chemical change takes place when a metal combines with oxygen or sulphur to form compounds
oxidize	• react with oxygen
periodic table	• an arrangement of elements in order of atomic number and properties
physical change	• any change in which the form of matter is different from the original without forming a new substance
recycle	• to make new products from used or unwanted materials
resistance	• the property that determines how much electricity will flow
smelting	• the process of extracting metal from its compound by means of heating it
steel	• alloy containing the metals copper and tin
sublimation	• change of solid into gas or gas into solid without going through the liquid phase
synthetic	• artificially made or not found in nature
tarnish	• a loss of lustre caused by a thin-coloured layer forming on an exposed metal surface
technology	• applied science including all devices, products, and processes used to solve practical problems
tensile	• capable of stretching with resistance to breakage

Periodic Table of Elements



*not yet synthesized as of 1993

Suggested Answers

Section 1: Activity 1

1. Answers will vary. Some objects or products that can be made from the common materials are listed.

   a. vehicles, machinery, appliances

   b. toys, containers, garbage bags

   c. clothing, carpets, upholstery

   d. sweaters, blankets, canvas tents

   e. dress material, drapery, bedding

   f. vases, figurines, tiles, dinnerware

   g. windows, lenses, light bulbs

   h. furniture, hockey sticks, fences, buildings

   i. tires, boots, elastics, erasers

2. Metal is one of the widely used materials because it is abundant, it can easily be changed into the desired shape, it is strong, and it will last if protected. Wood is also one of the most widely used materials because it is abundant, inexpensive, easy to work with, and can easily be changed into the desired shape.

3.

Homogeneous Material	Heterogeneous Material
milk beer bottle cutlery credit card looney coin	violin newspaper house electric cord chesterfield toilet bowl/tank

4. Answers may vary.

Item	Materials
scissors	• steel • plasic • chrome
gas barbecue	• metal firebox • rubber wheels • wood racks • plastic dials
hammer	• metal head • wood, fibreglass, or rubber handle
car	• rubber tires • metal body • fabric seats • plastic instrument panel • glass windows
airplane	• rubber tires • metal body • fabric seats • glass windows
microscope	• plastic or metal body • glass lenses
sneakers	• rubber soles • plastic or synthetic uppers • fabric laces

Item	Materials
personal computer	• plastic body • metal circuits • glass screen
sleeping bag	• metal zipper • natural or synthetic fill • fabric bag
hockey stick	• wood or metal shaft and blade • plastic reinforcement • other glue
pen	• plastic or metal body • ink
guitar	• wood or plastic body • metal or plastic strings
toaster	• metal or plastic body • metal heat coil • metal and rubber cord

Section 1: Activity 2

1. The objects are classified as matter because they have mass and occupy space.
2. Atoms would be the result of molecules that were broken apart.
3. There are three kinds of atoms that are found in the sugar molecule: carbon, oxygen, and hydrogen.
4. There are twenty-four atoms in the sugar molecule.

Section 1: Activity 3

1. a. D

   b. F

   c. B

   d. E

   e. A

   f. C

2. The music is analagous to heat. If the amount of heat is reduced, the molecules can slow down and form a solid.

Section 1: Activity 4

1. No, you cannot see the marshmallows moving around in the jar.

2. A solid is being modelled. The marshmallows are not free to move about in the jar just as the molecules in a solid do not freely move about.

3. Yes, you can see the marshmallows moving around in the jar.

4. A liquid is being modelled. The marshmallows slide over one another as the jar is tilted from side to side just as the molecules in a liquid move.

5. Yes, you can see the marshmallows moving around in the jar.

6. A gas is being modelled. The marshmallows move vigorously and fill the entire jar just as the molecules in a gas move vigorously and take up space.

7. A liquid can occupy the entire volume. If you fill the jar with marshmallows, you are modelling a solid; the marshmallows are not free to move.

8. You can easily see the multi-coloured marshmallows shift position compared to plain, white marshmallows.

9. Answers will vary.

Solids	Liquids	Gases
• bar of soap • fork and spoon • drinking glass • shovel • canned food containers • stove and other appliances • clock • toaster	• paint thinner • milk • soda pop • bleach • household cleaners • vinegar • shampoo • gasoline for lawn mower	• carbon dioxide in pop • natural gas • furnace exhaust • moisture in air • ammonia vapour from cleaners • aerosol can propellents • air • freon gas in refrigerator coils

Section 1: Activity 5

1. a. sublimation

   b. solidifying

   c. sublimation

   d. evaporation

   e. condensation

   f. fusion

   g. condensation

   h. evaporation

   i. fusion

2. a. The change is chemical because new substances, carbon dioxide and water vapour, are formed.

   b. The change is physical because the gravel remains the same except it is in smaller pieces.

   c. The change is chemical because a new substance is formed.

   d. The change is chemical because a new substance is formed.

e. The change is physical because it is the same substance in a different form.

f. The change is physical because it is the same substance in a different form.

g. The change is chemical because a new substance, silver oxide, is formed.

h. The change is physical because it is the same substance in a different form.

Section 1: Activity 6

1.

Atomic Number	Symbol	Name
1	H	hydrogen
3	Li	lithium
6	C	carbon
12	Mg	magnesium
15	P	phosphorus
17	Cl	chlorine
20	Ca	calcium
26	Fe	iron
32	Ge	germanium
47	Ag	silver
74	W	tungsten
80	Hg	mercury

2. *Mineral* was the word used to describe the known elements in ancient times. Those known elements were mainly metals and the components of rock. After gaseous elements were discovered, it must have seemed incorrect to call a gas a mineral. The word *element* is used to describe all elements that are solids, liquids, and gases. Mineral describes the solid elements only.

3. To date, 109 elements have been discovered. Element 108 has not been discovered. Elements 109 and 110 have been discovered, but there is little verification of the discoveries.

4.

Symbol/Name	Metal/Nonmetal
iridium	metal
Te	nonmetal
vanadium	metal
Cr	metal
Au	metal
argon	nonmetal
selenium	nonmetal
F	nonmetal
barium	metal
Br	nonmetal

5.

Element	Compound
calcium carbon iron zinc mercury silver	carbon dioxide alcohol baking soda propane table sugar vinegar

6.

Mixtures	Not Mixtures
soil air sea water crude oil milk	sugar distilled water zinc

7. a. Soft drinks are composed of water, sugar, flavour, and colour.

   b. Air is composed of nitrogen, oxygen, and carbon dioxide.

   c. The main ingredients of paint are pigment or colouring, solvents (water, linseed oil, or a petroleum base), and solutes such as latex or oils.

   d. The components of pavement are tar or asphalt and gravel.

   e. A 10 karate gold ring is composed of gold, silver, copper, and possibly other metals.

Section 1: Follow-up Activities

Extra Help

1. a. plastic, iron, chromium

   b. glass, silver

   c. fabric, plastics

   d. wood, plastic, metal, ceramics

   e. metal, plastic

   f. ceramic, plastic, wood, glass, metal

   g. metal, glass, plastic

   h. wood

   i. glass, plastic

2. A cloud has mass and it occupies space. It is usually composed of small drops of liquid water or small crystals of ice.

3. a. **T**

   b. **T**

   c. **F** An atom is the smallest particle of an element.

   d. **F** The kinetic molecular theory states that when water freezes, the molecules vibrate in fixed places. The theory states that all motion ceases at – 273.15°C.

   e. **T**

   f. **F** According to the kinetic molecular theory, gases have the greatest amount of space between their molecules.

   g. **T**

   h. **T**

   i. **T**

   j. **T**

   k. **T**

4. a. Sulphur is an element; therefore, it contains only **one kind** of atom.

   b. The formula for baking soda is $NaHCO_3$. The elements that baking soda is made from are **sodium**, **hydrogen**, **carbon**, and **oxygen**.

   c. The space between molecules in gases is **very large**.

   d. The state of matter that has a definite volume is a **solid** or **liquid**.

5. a. C

   b. A

Enrichment

1. a. Potassium is required for proper muscle and nerve function.

   b. Magnesium regulates nerve and muscle action.

   c. Sodium regulates the balance of body fluids and transmits nerve impulse.

   d. Calcium aids bone structure, muscle contractions, and blood clotting.

   e. Chlorine provides an acid-base balance.

   f. Phosphorous is necessary for healthy bone structure.

   g. Copper is necessary for hemoglobin formation.

   h. Cobalt is essential for hemoglobin formation.

   i. Zinc is important in many enzymes.

   j. Iodine is part of the thyroid hormone.

   k. Fluorine hardens bones and teeth.

   l. Iron reduces bacterial action in the mouth, and it is an important component of hemoglobin.

   m. Sulphur is an important part of proteins (such as insulin).

2. The container with hot water promotes the spreading of food colouring more quickly.

3. The collision of water molecules with food colouring molecules causes the food colouring to diffuse in water.

4. Temperature increases collisions since diffusion occurs more quickly in warm water.

5. Diffusion occurs more quickly; therefore, there must be more collisions involving food colouring molecules occurring when the concentration increases.

6. Since molecules are in motion, they collide with one another. Gas and liquid molecules collide with other molecules.

Section 2: Activity 1

1. Gold is very stable and unreactive with most elements or compounds. There are some elements, such as arsenic and mercury, which react with gold, but these elements are not commonly found in their pure state.

2. Prehistoric people worked with gold, copper, and tin. Thus, they were the first metallurgists.

3. Bronze is harder and stronger than copper.

4. Carbon does contaminate iron in the same way, but if the amount of carbon is just right, steel is produced instead of iron. The steel can be stronger and harder than pure iron.

5. Many of the metals cannot be refined by smelting. Until chemical, physical, and electrical processes were discovered, many metals remained hidden in their ores. Other metals are found in very low concentrations so that conventional methods could not detect the presence of these metals.

6. The ore, bauxite, and a large supply of inexpensive electricity are required. The bauxite is imported from Brazil, Guyana, and Guinea and it is refined where the electrical power is the least expensive, which could be in British Columbia.

7. a. galvanized steel, zinc-plated steel, aluminum

   b. chrome-plated steel

   c. chrome-plated steel

   d. vanadium steel

   e. sterling silver or stainless steel

   f. cast iron, aluminum, stainless steel

   g. copper

   h. stainless steel

8. a. 1535°C

   b. 1083°C

   c. 328°C

   d. 631°C

   e. 232°C

f. 962°C

g. –39°C

h. 29.8°C

Section 2: Activity 2

1. Iron is the easiest to obtain from the ore and therefore will oxidize the slowest. However, iron does not form a protective coating of iron oxide (rust) as does aluminum. The aluminum oxide coating forms very quickly, but then it protects the aluminum metal from further oxidation.

2. The metal garbage can is galvanized to protect it from rusting. Metal garbage cans are made from steel which is then plated with zinc. The zinc quickly oxidizes but the oxide layer prevents further oxidation. Galvanizing is the coating of zinc onto another metal usually steel.

3.

Corrosion of Iron			
Container Number	**Content Descriptions**	**Day 1 Observations**	**Day 2 Observations**
1	bent nail in water	more rusting at bend	more rusting at bend
2	nail wrapped in transparent in water	no rust under tape	no rust under tape
3	nail wrapped with Cu in water	no rust under Cu	no rust under Cu
4	clean nail in water	rusted	rusted
5	nail in NaCl	no rust	no rust
6	nail in $CuSO_4$	no rust	corrosion
7	nail in HCl	no rust	no corrosion
8	clean nail in empty container	no rust	no corrosion

4. Container 8 is the control.

5. The nail that corroded the most was the one in the $CuSO_4$ mixture, which was container 6.

6. The nail that corroded the least was the one in air, which was container 8.

7. For the rusting of iron to occur, water is needed. Rusting will occur faster where the iron is bent.

8. In container 6 you should notice corrosion that is different and faster than the rusting in container 1 to 4. The corrosion you see is actually copper that is plating onto the nail. Look carefully and see if you can see a red or copper-coloured metal on the nail.

   There are tiny bubbles being produced on the nail in container 7. This indicates a chemical reaction but there is no corrosion visible. The hydrochloric acid is reacting with the iron, and hydrogen gas is being produced. The iron is being eaten away by the acid. Once all of this acid is used up you will start to see rust forming.

9. The paint coat on a car can be broken by stones or dents.

10. Some car parts made from chrome-plated steel are given.

    - bumper
    - headlight trim
    - radiator grill
    - control level and knobs
    - door opener
    - window crank handle

11. Chrome-plating produces a bright, shiny surface which is highly resistant to corrosion. Bumpers, trim, and handles enhance the beauty of a car when they shine. Paint could not produce such a surface that would last for years.

12. Galvanized steel is strong, corrosion resistant, and inexpensive.

13. A steel bridge supports a huge amount of weight such as trucks or trains. Corrosion of the steel could lead to the bridge collapsing.

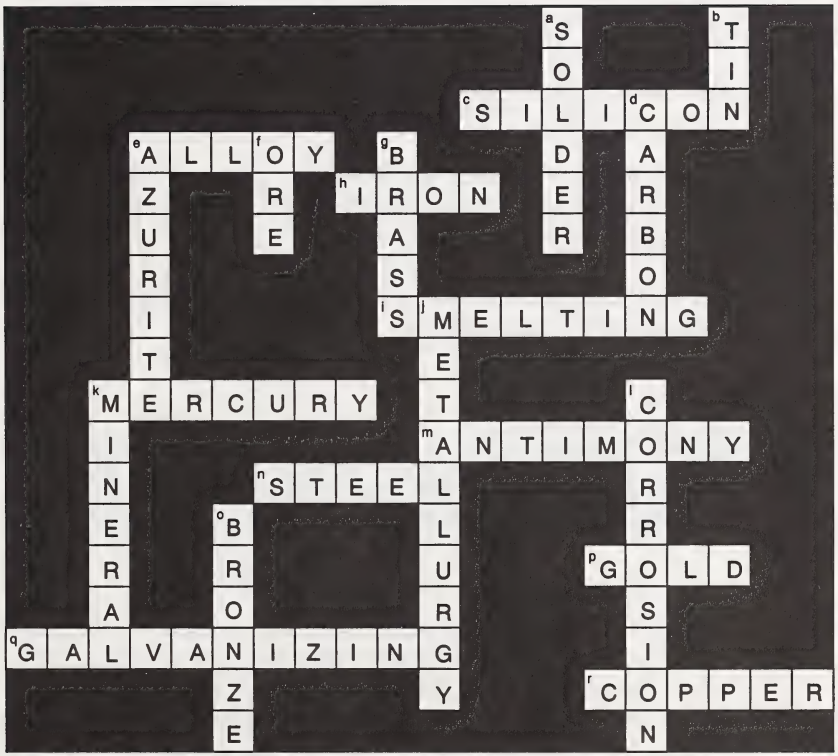
14. Replacing a battery above ground level is easier than replacing a metal block underground. It is probably an inexpensive and more effective protection.

15. Storage tanks for fuels such as gasoline and diesel fuel and pipelines are a serious potential hazard if they start to leak. Pollution of groundwater and explosion are but two of the risks of an underground storage tank or a pipeline leaking due to corrosion.

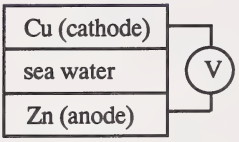
16. Tin-plating is expensive and very hard to completely cast over a large surface. If the tin layer is punctured, the iron or steel underneath will quickly rust away. You might want to see just how fast a tin can will rust. Take a tin can and scratch through the tin coating in a few places. Then leave the can outside in a moist place and see how fast the iron rusts.

Section 2: Follow-up Activities

Extra Help

1. B
2. A
3. D
4. B
5. C and D
6. C
7. B
8. 

Enrichment

1. 

Zinc metal loses electrons (oxidation) to copper ions which gain the electrons (reduction). Electrons flow from where they are produced (anode) to where they are needed (cathode). Sea water is an electrolyte (electron charge carrier) which allows the electrons to flow from the zinc to the copper.

2. Inexpensive metals are often produced by smelting inexpensive coal. This coal contains large amounts of sulphur. When society demands a great amount of inexpensive metals, the amount of sulphur dioxide in the atmosphere increases dramatically. This gas is directly responsible for acid rain.

   As is the case too often in modern society the negative effects of a technology are often far removed from the products being consumed.

Section 3: Activity 1

1. An object that has a shiny surface is said to be lustrous.

2. Copper combines with oxygen or sulphur to produce a dull, non-lustrous corrosion coating on its surface.

3. Silver combines readily with sulphur in the atmosphere to produce a dull, unattractive tarnish. Therefore, some people may not want to own silverware because frequent polishing is needed to restore and maintain the brilliant shine of polished silver.

4. The black film that develops on silverware is called tarnish. It is formed when silver reacts with the sulphur compounds found in the atmosphere.

5. Answers will vary.

Time in Thirty-second Intervals	Observations
1	Some tarnish starts to disappear.
2	More tarnish disappears; foil starts to discolour.
3	Still more tarnish disappears; foil has black appearance.
4	Very little tarnish remains; foil has black appearance.
5	Almost no tarnish remains; foil has black appearance.

Time in Thirty-second Intervals	Observations
6	No tarnish remains; foil is black.
7	No tarnish remains; foil is black.
8	Object is shiny; no tarnish; and foil is black.
9	Object is shiny; no tarnish; and foil is black.
10	Object is shiny; no tarnish; and and foil is black.

6. The tarnish began disappearing immediately.

7. The tarnish completely disappeared in about three minutes (six time intervals).

8. The aluminum foil was very shiny before the investigation.

9. At the end of the investigation the aluminum foil was black.

10. As the tarnish disappeared from the silver, the aluminum foil became tarnished. No silver was lost in the process; the silver sulphide was turned into silver. This was accomplished by a chemical reaction.

Section 3: Activity 2

1. Gold, platinum, and silver are only used in special circuits because they are very expensive.

2. Iron is not used for electrical wiring because it is a poor conductor compared to copper and aluminum.

3. Aluminum is a very soft and very ductile metal. Aluminum power lines would stretch and sag because of its softness. Copper is much harder and not as ductile as aluminum. Copper wires can support their own weight.

   Aluminum was used for household wiring at one time but corrosion and fire problems developed when aluminum was joined to copper junctions.

4. Melting point of tungsten must be higher than the melting point of iron since it is used in bulb filaments which would melt iron.

5. There are many possible answers. Carbon filaments are very fragile and the slightest bumping can make them break. The tungsten filaments are much more able to handle rough treatment such as shipping.

   The efficiency of light bulbs decreases over time because the filament vapourizes slowly and coats the inside of the bulb with a dark film preventing the light from escaping. It is inexpensive and more energy efficient to replace the bulbs than to use them until they only emit a fraction of the light they should. Actually filament type bulbs are made to burn out after a certain number of hours of use.

6. The two metals used to make the Nichrome alloy are nickel and chromium.

7. Although copper is a good conductor, the large size of the stove element requires a metal with a higher resistance like iron. Also copper is much softer than iron and would wear out too quickly.

8. You answers will vary. For each metal and nonmetal one example is given.

Metal	Object	Conductivity
Aluminum (Al)	pop can	yes
Lead (Pb)	solder	yes
Zinc (Zn)	garbage can	yes
Iron (Fe)	steel wool	yes
Copper (Cu)	brass key	yes
Tin (Sn)	tin can	yes
Silver (Ag)	silverware	yes
Nickel (Ni)	post-1968 nickel coin	yes
Chromium (Cr)	water faucet	yes

Nonmetal	Object	Conductivity
Carbon (C)	carbon paper	yes
Wood	paper	no
Plastic	cassette case	no
Glass	jar	no

9. It can be concluded that metals are electrical conductors.

10. Metal alloys also conduct electricity.

11. It can be concluded that nonmetals, with the exception of carbon, do not conduct.

12. Carbon is one of the few nonmetals that conducts electricity.

Section 3: Activity 3

1. Some things that depend on the use of magnets are electric motors, security systems, and coin machines.

2.

Metal	Object	Magnetism
Aluminum (Al)	pop can	no
Lead (Pb)	solder	no
Zinc (Zn)	garbage can	no
Iron (Fe)	steel wool	yes
Copper (Cu)	brass key	no
Tin (Sn)	tin can	yes
Silver (Ag)	silverware	no
Nickel (Ni)	post-1968 nickel coin	yes
Chromium (Cr)	water faucet	no

Nonmetal	Object	Magnetism
Carbon (C)	carbon paper	no
Wood	paper	no
Plastic	cassette case	no
Glass	jar	no

3. Only iron, nickel, and sometimes tin are magnetic. There are no nonmetal materials that are magnetic. There is another uncommon metal, cobalt, which is also magnetic, but the chances of you having a cobalt item are very slim.

4. Nonmetals are not magnetic. Only iron, nickel, and cobalt are magnetic.

5. Fe, Ni, and Co are arranged side by side on the periodic table. They form a triad.

Section 3: Activity 4

1. You could try bending the spoon slightly. If it bends and does not spring back to its original shape it is probably made from a light metal. If it breaks or springs back into its original shape it was probably made from plastic. Metals are malleable and plastics are not.

2. The wings and supports of an airplane must be light but flexible. If the wings or structure were made from an alloy which is easily bent, the airplane would quickly be bent out of shape and be useless for flying.

3. a. A car is malleable. In a crash the metal parts are bent out of shape.

   b. A pop can is malleable. You can crush an empty pop can.

   c. A pencil is not malleable. If you bend it it will break or return to its original shape.

   d. A kitchen knife is not malleable. It returns to shape when you try to bend it. Be careful; if you bend it too far it can break in a very dangerous way.

   e. A coat hanger is malleable. If it is made of metal, it will bend. If it is made of plastic, it will not be malleable but it will break.

4. Sample answers are given. A question mark indicates that that particular object may or may not be malleable. However, the object may be mixed with another metal, thus giving it unique qualities.

Metal	Object	Malleability
Aluminum (Al)	pop can	yes
Lead (Pb)	solder	yes
Zinc (Zn)	garbage can	yes
Iron (Fe)	steel wool	yes
Copper (Cu)	brass key	?
Tin (Sn)	tin can	yes
Silver (Ag)	silverware	?
Nickel (Ni)	post-1968 nickel coin	?
Chromium (Cr)	water faucet	no

Nonmetal	Object	Malleability
Carbon (C)	carbon paper	no
Wood	paper	no
Plastic	cassette case	no

5. Most metals are malleable. The exceptions may be due to other alloys being mixed in with the metal being tested.

6. No, there weren't any malleable nonmetals.

7. Metals are generally malleable while nonmetals are not malleable.

8. You could generalize that metals are ductile while nonmetals are not ductile.

9. Gold is very dense and would make very heavy wires. Since it is also very ductile, the heavy power lines would cause the wire to stretch.

Section 3: Follow-up Activities

Extra Help

1. a. Metals that are shiny are said to be **lustrous**.

   b. A shiny metal is **chromium**, which is plated over other metals.

   c. **Aluminum** metal is a good conductor of heat and is used to make pots and pans.

   d. **Copper** metal is a good conductor of electricity and is used for household wiring.

   e. Metals that are attracted to magnets are **iron**, nickel, or cobalt.

   f. Metals bend or are said to be **malleable**.

2. i. e

   ii. d

   iii. j

   iv. g

   v. a, c, e

   vi. i

   vii. a

   viii. b

   ix. h

   x. f

Enrichment

1. Answers will vary but may include some or all of the following suggestions:

   - Steel sheet metal or galvanized steel are used for the body and frame of the car because the metal can easily be bent into the desired shape and corrosion is reduced.

   - Chromium plating on steel bumpers and body trim is used to prevent corrosion and produce an attractive and shiny appearance.

2. a. Metals would need to be malleable. Thus they could easily be bent into shape and then "memorize" that shape.

   b. This could reduce the costs of getting eyewear fixed. It also could contribute to having eyewear with a better fit.

   c. A disadvantage of doing this would be that manufacturers would have decreased sales. However, the cost of the eyewear might also increase. This would be beneficial to the producer but not to the consumer.

Section 4: Activity 1

1. Iron is used extensively because it is abundant, fairly inexpensive, strong, and can easily be changed into a desired shape.

2. a. **C. Plated Steel**

   b. D. Stainless Steel

   c. C. Plated Steel

   d. E. Special Steels

   e. A. Iron

   f. C. Plated Steel

   g. A. Iron

   h. B. Coated Iron and Steel

   i. C. Plated Steel

   j. B. Coated Iron and Steel

   k. A. Iron

   l. E. Special Steels

3. Copper is used in the armature coil of an electric motor.

4. Copper is used in plumbing because it is more resistant to corrosion than iron.

5. Some brass objects include decorative buttons, belt buckles, rings, hardware, door hinges and knobs, keys, beds, railings, coffee tables, shelving, figurines, and giftware.

6. Aluminum foil is sometimes called tinfoil because tinfoil has been in existance and in use long before aluminum foil was.

7. Copper utensils are not common because they are more expensive. Also, they are too soft, and thicker copper can react with certain foods.

8. Aluminum is a desirable metal for many applications for several reasons. It is very abundant, inexpensive, and one of the lightest metals. It is very ductile, corrosion resistant, and a good conductor of heat and electricity.

9. Galvanized sheet metal is used for eavestroughing, furnace heating ducts, and garbage cans.

10. Galvanized sheet metal is not used for bakeware because the melting point of zinc is fairly low (420°C). It is also more dense than aluminum due to the iron content.

11. Environmentalists do not want lead compounds used in gasoline because they are poisonous. The lead compounds collect on streets from car exhaust and end up in rivers from rain and melting snow. Also, the water that people drink may come from polluted rivers containing these lead compounds.

12. Lead-based paints on pencils and baby furniture were frequently ingested because of people biting on the objects; therefore, the poisonous lead was also ingested.

13. Lead solder is used to make connections in electrical circuits and plumbing joints.

14. Iron, copper, and aluminum are used to make more objects than any other metals because they are the most abundant metals found.

15. The price of silver was higher than the value of the coin.

Section 4: Activity 2

1. The following are problems that could arise from promoting a metal recycling program:

   - Any new program of production will create new jobs but may destroy some jobs in the original production process. This adjustment is often met with resistance.

   - Recycling sometimes produces new and undesirable wastes or products of little value. A good example is the current problem faced by society regarding the recycling of used tires.

   - Recycling dangerous metals is often very expensive. An example is discarded batteries, both nonrechargeable, which contain mercury and other metals, and rechargeable, which may contain cadmium, lead, or other toxic metals.

   - Many consumers still feel recycled products are inferior to products produced with original materials. These attitudes are often very hard to change.

2. Recycling waste metal is better for two main reasons:

   - Valuable mineral resources are conserved.
   - Less metal in landfills means less chance of polluting water, land, and air.

3. There is only a tiny fraction of metals which cannot be recycled. This fraction is lost to corrosion or wear. If everyone ensured that no metal objects were disposed of in a landfill and that all objects were recycled regardless of cost, all metals could be recycled. In reality it is very difficult to recycle all metals.

4. Household metal wastes come from products that were used in the home and the products or containers must be disposed of once they have served their purpose. Industry operates on a larger scale and uses more toxic metals in reactions that are sometimes complex. A good example is the nuclear industry which uses and produces radioactive metals. Households use and produce very tiny amounts of radioactive wastes in applications such as smoke detectors.

5. Toxic metals and the products containing them should be sent to the Alberta Special Waste Treatment Centre or to a proper recycling plant. Lead from batteries can be recycled, but PCB-contaminated metals cannot be recycled.

Section 4: Follow-up Activities

Extra Help

1. a. galvanized or chrome-plated steel

   b. galvanized steel

   c. aluminum

   d. copper

   e. aluminum

   f. galvanized steel

   g. copper

   h. iron and zinc

   i. galvanized steel

   j. lead

   k. silver

   l. galvanized steel

2. a. **T**

   b. **T**

   c. **F** Zinc has a fairly low melting point.

   d. **T**

   e. **F** The Alberta Special Waste Treatment Centre accepts special wastes for disposal.

   f. **F** PCB-contaminated transformers are not disposed in municipal landfills.

   g. **T**

   h. **T**

   i. **T**

   j. **F** Aluminum foil can either be shiny or dull.

Enrichment

1. Gold panning for beginners requires only a few simple tools. You will need a spade (a pointed shovel), a gold pan (a special pan made of plastic or metal often with a set of ridges on the inside), a small plastic bottle used to pick up any gold flakes, and some gold-bearing gravel in a river.

   Shovel some gravel into the pan. Dip the pan into the water and wash off the larger stones into the pan. Swirl the contents of the pan so that the more dense particles (the gold and black sand) settle to the bottom. Use your finger or the swirling action of the water to periodically remove the top layer of sand. This process is continued until you are left with a small amount of black sand and hopefully some gold. The gold is suctioned into the plastic container.

2. The Alberta Special Waste Treatment Centre in Swan Hills is a modern, high-technology disposal plant. The basic principles involved in handling the special wastes are as follows.

   - Wastes are placed into steel barrels and transported to the centre by special trucks.
   - None of the wastes or containers that enter the plant ever leave.
   - The wastes are tested to determine the chemicals involved and then are treated accordingly.
   - Some wastes are treated chemically.
   - Some wastes are incinerated (burned at very high temperatures), and all waste gases are collected.
   - The ashes are treated and processed with cement to produce inert blocks.

- The inert blocks are deposited in a specially lined covered pit. When the pit is full it is covered with plastic, clay, soil, and planted with grass.
- Treated liquids are injected into very deep wells.
- Materials which cannot be treated are stored in special containers and buildings.
- The entire centre is surrounded by drainage facilities which prevent any fluids from escaping to the surrounding environment.

NOTES

NOTES

NOTES

NOTES

L.R.D.C.
Producer

Science 24

9SC24P25

1992